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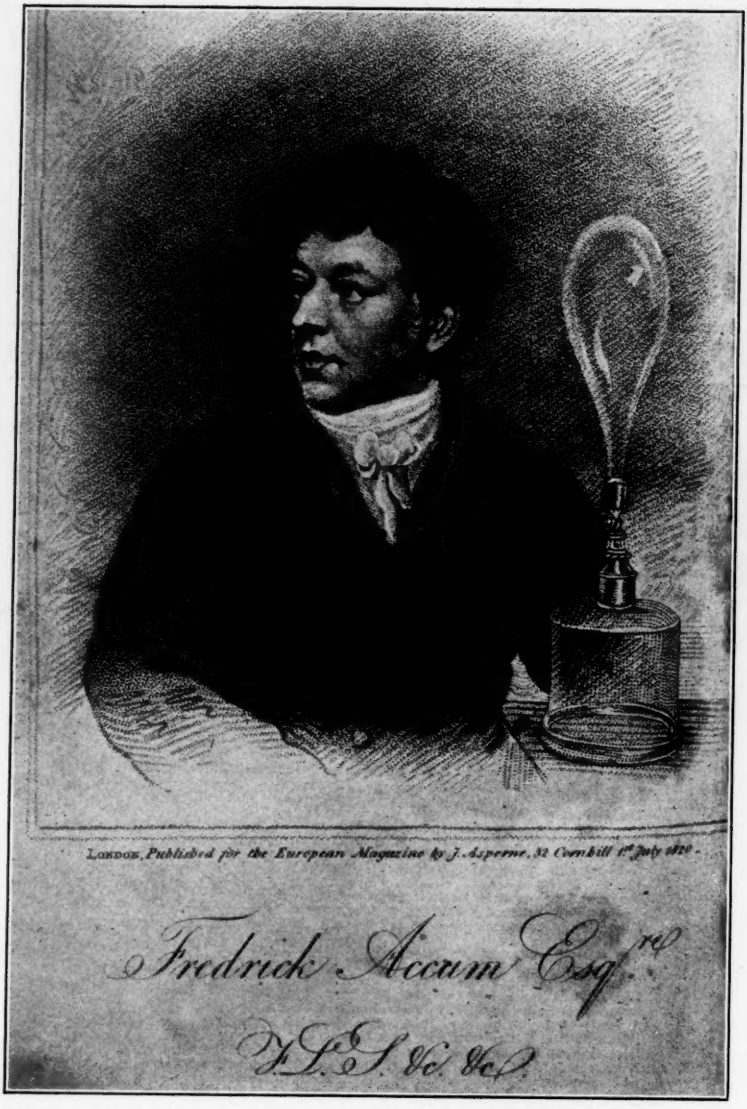


(Engraved by J. Thomson from an original painting by S. Drummond and published in the European Magazine for July, 1820.)

EDITOR'S OUTLOOK

IN AN age when specialization has become the rule and versatility is suspiciously viewed as probable evidence of superficiality, we are frequently amazed at the scope of the activities of earlier chemists.

Fredrick Accum

Fredrick Accum, whose portrait from Dr. C. A. Browne's collection constitutes the frontispiece in this number, was an outstanding example. Lecturer, dealer in scientific supplies, investigator, pure-food agitator, industrial expert, and what-not; he was one of the most picturesque of those historic characters who have, in the course of time, almost slipped into oblivion.

In Dr. Browne's dramatic account of his life, of which the first installment appears herewith, he lives again. The author has kindly furnished us with such portions of his collection of Accumiana as are suitable for journalistic reproduction. We trust that our readers will discover in this series the same interest and entertainment which we enjoyed in our first examination of the manuscript.

WHY a Senate of Chemical Education? What are its functions? These questions are partially answered on page 882–3 of this number of the JOURNAL but a moment's consideration of the state organizations is necessary in order to arrive at an understanding of the origin and full possibilities of such a body.

Senate of Chemical Education

At the Ithaca meeting of the A. C. S. (1924), the Section of Chemical Education was made a Division, and THIS JOURNAL was incorporated as its official organ. This made it evident that interest in chemical education had become firmly established, and that a definite nation-wide program was necessary. In view of these considerations, the Division proposed to encourage organization of chemical education in each state in one of three ways, namely:

1. Around the local sections of the A. C. S.
2. Through independent associations of chemistry teachers.
3. Through sections of the State Teachers' Associations.

Each state has carried out the plan which has seemed best fitted to its local needs. The organizations have developed until, today, teachers in over three-fourths of the states are organized in one of the three forms outlined above.

Because of our form of government, the state is the natural unit of organization. Each state has its own system of education; therefore, any A. C. S. educational project must be adopted individually by the states before it can become national. Each state should have its own

plan, outlined by men of sufficiently broad vision to realize that chemical education should not stop at the school and college halls, but should be carried to those engaged in all professions and walks of life.

The Division is anxious that the state organizations become strong and effective as the accredited agencies of the American Chemical Society for coöperative national work in chemical education, and that they merit and receive the respect and confidence of the educational forces of their respective states. It is the plan of the Division to carry out its policies through the state organizations as far as possible and to delegate to them all the responsibility feasible, for it must look to them to maintain standards and carry forward programs which shall be sound chemically as well as educationally.

It is clear that the success of a nation-wide movement in chemical education will be determined, very largely, by the strength and efficiency of the respective state units and the degree of coöperation which they accomplish in the prosecution of any national policy. The Senate is to form the official link between the various state organizations, hence it is important that the senators be carefully chosen. Of course, it is highly desirable to have men who are well trained and thoroughly experienced in chemical education, but there are other requirements. It is equally important that these men have the vision to perceive the possibilities in chemistry and the importance of a nation-wide program of chemical education, if our nation is to take the lead in our great science.

Accomplishment under Difficulties

WE HAVE lately received from Professor V. Verkhorsky of Leningrad, a charming letter in which he tells us something of his work in the Russian capital. Copies of several of his text-books accompanied the letter. They are printed on cheap stock and poorly bound in paper because, as he explains, it is at present impossible to obtain from Russian publishers editions executed and bound in the sumptuous style of our American texts.

Reading between the lines (which we find more intelligible than the Russian script itself) and examining the wealth of carefully prepared drawings with which the subject-matter is illustrated and explained, we are filled with a sentiment of admiration for those earnest devotees of science who are laboring so faithfully with such scanty material.

The teacher in the small, poorly equipped high school, could he see the ingeniously contrived apparatus used in lieu of unobtainable or excessively costly fixtures which we have come to take as a matter of course in our laboratories, would be newly inspired with the will to carry forward

under difficulties. To cite but one example, there are all-wood stands and clamps to do duty for the metal ones which could not be had during the war nor immediately thereafter. Strong and simply constructed, they are not nearly so clumsy nor inefficient as one would expect.

We respect and admire the spirit in which these men have met and, as far as possible, overcome the obstacles in their paths and we join with all lovers of science in hoping that they will shortly come on better times.

Industrial Achievement

THE Tenth Exposition of Chemical Industries, which completed its one-week span of existence at the Grand Central Palace in New York on October third, was in some respects the superior of all its predecessors. Certainly, with reference to effectiveness of display and to the number and importance of the processes represented, it outshone previous efforts.

The emphasis was, quite properly, mainly technical, yet nearly every exhibit contrived, without sacrificing its primary objective, to present features of unusual interest to the academic chemist and the layman. Particularly successful from this standpoint were the various textile displays, with the synthetic silks outstanding—the natural result, no doubt, of the almost unlimited opportunities for effective manipulation of color and design which exist in that field.

To the student of chemistry, however, the most gripping and inspiring of the exhibits present were those which gained admission to the Court of Chemical Achievement. Not that they were, in general, singularly striking or pretentious from the showman's point of view. Quite the contrary. Their appeal was of a nature better adapted to intrigue the mind's eye than to astonish and delight the physical vision. They might be considered as the colored pins which the science of chemistry has thrust into its terrain map to mark the recent advances on various fronts in the course of man's campaign to conquer his material environment.

As such, they induce a justifiable pride and a comfortable sense of accomplishment—a feeling that it is both a privilege and an opportunity to engage in a pursuit which can produce such convincing evidence of its effectiveness. Yet the mood one carries away is not one of complacent satisfaction with present gains—a willingness to rest upon honors won. Each achievement displayed suggests to the imagination a host of hitherto unconsidered possibilities. The sense of something accomplished, far from destroying the incentive to further effort, inspires the beholder with a confidence that difficulties overcome and problems solved extend a promise of success for future honest effort. The chemical industries, we are glad to note, are still looking forward.

ANY note on the Tenth Exposition would be incomplete if it did not include a tribute to Mr. W. T. Read and others instrumental in the arrangement of the students' courses in chemical engineering.

Students' Courses

One course was designed for elementary and general students and another with a view to enabling advanced students to familiarize themselves with recent developments in industrial practice.

The attendance was larger than at any previous gathering and more institutions were represented. The courses were so conducted that students who attended could, through proper arrangements with their respective colleges, receive scholastic credit for work done.

It was quite evident that the opportunities thus extended were highly appreciated and that the lectures presented were well calculated to further the aims of the committee by stimulating an interest in science and attracting more students into the field of industrial research.

THIS issue of the JOURNAL includes a full account of the minutes of the joint session of the Division of Chemical Education and the Section of History of Chemistry at the Los Angeles meeting of the A. C. S. No doubt many of our readers are awaiting with impatience an opportunity to examine the papers presented there. A considerable portion of the November number will be devoted to the publication of that material.

The Symposium on Objectives

The question of objectives is obviously a vital one. Many of us have felt at times that not a little profit might reasonably be expected to accrue from some thoughtful consideration and intelligent discussion of just what we, as chemistry teachers, are attempting to accomplish. It was hardly to be hoped that one meeting, however excellent, could obviate all difficulties and reconcile all conflicting views, nor did it. On the whole, however, the symposium just past represents a definite step towards the clarification and coördination of our ideas on aims and purposes.

THE LIFE AND CHEMICAL SERVICES OF FREDRICK ACCUM

CHARLES ALBERT BROWNE, CHIEF, BUREAU OF CHEMISTRY, WASHINGTON, D. C.

Introduction

It was the fortune, or perhaps the misfortune, of the chemist whose services are reviewed in these pages to be born in one of the most eventful years of history. Astronomically, the year 1769 was distinguished by transits of the two planets—Venus and Mercury. The coincidence of these two events in the same year occurs perhaps not oftener than once in a thousand years, so it is not surprising that astrologers in reading the signs of 1769 should say that the indications were momentous and that those born in this year were predestined to great fortune, or to great misfortune, as the case might be.

In births of eminent men probably no other year can furnish such a record as 1769. Omitting many persons of less importance, we need only mention among soldiers Napoleon, Wellington, Marshal Ney, and Marshal Soult; among statesmen, Castlereagh; among artists, Sir Thomas Lawrence; and among scientists, Alexander von Humboldt, and Cuvier. As regards inventions, it was in 1769 that James Watt patented his steam engine and Arkwright his spinning frame—two determining factors in the great industrial revolution of which the origin belongs to this time. On February first of this same year, Lavoisier completed his first quantitative experiments with the balance, so that we may assign to this date the first beginning of that work which, in the next twenty-five years, was to establish the foundations of modern chemistry. In America also, this year marked the commencement of another era in science, for in 1769 the first professorship of chemistry in the new world was established by the appointment of Dr. Benjamin Rush to the chair of chemistry in the medical department of the University of Pennsylvania.

From 1769 it is only the span of a life-time to 1837 when Dumas first summarized the outcome of Lavoisier's work in his famous "Leçons sur la Philosophie Chimique." Indeed if one should select the great chemists—fully one hundred in number—who were living on that memorable eighth of May in 1794, when Lavoisier ascended the scaffold, it would be found that the average period of their lives extends from 1769 to 1838, and these were the years, respectively, of Accum's birth and death. Apart from its unparalleled historic importance this period was of the greatest significance to chemistry. It witnessed not only the overthrow of the phlogiston theory and the establishment of our present ideas regarding the molecular constitution of matter, but it saw also the rise of many new chemical industries, such as those of soda, bleaching, beet-sugar, and gas lighting. It witnessed not only the establishment of special schools and laboratories for training chemists as investigators and teachers, but it saw also the growing

development of the technical and industrial chemist. The latter, in manufacturing and in other ways, undreamed of by the old alchemists, succeeded even in Lavoisier's time in transmuting his chemical knowledge into gold. Yet there were difficulties which confronted this new profession of practical chemistry. Not only were there no industrial schools in which training could be obtained, but the employment of pure science as a means of profit was looked upon by many with disfavor. This narrow conception of a pure and of an impure, or applied, science was well satirized at the time by Schiller in a famous couplet, which may be paraphrased:

> Science to one is the mother revered by the gods; to another
> Only a cow whence to squeeze profits in butter and cheese.

It must be admitted, however, that there were circumstances which tended to justify this conception of an impure science. This was seen especially in the appearance of a multitude of quacks and impostors who made unlawful uses of the new discoveries in chemistry. The adulteration of food and of other necessities began to be practised to an almost unlimited degree and in ways so subtle as to escape detection. The occasion demanded a special type of scientist to cope with the new problems of adulteration and so it happened that in this period the food chemist appeared for the first time.

Yet after all there is a remarkable similarity between the activities of the practical chemist one hundred years ago and the same activities of today; there were similar men, similar conditions, similar problems. This can be illustrated in no better way than by the career of the man whose life work is now to be considered.

Chapter I

Parentage, Education, and Establishment in London

Friedrich Christian Accum was born March 29, 1769 (the same day as Marshal Soult), at Bückeburg, a small town in Germany about twenty miles southwest of Hanover. Of his youth very little is known. Accum was never communicative about his early life and the unsettled condition of Europe during that troubled period has left gaps in many biographies.

His father was a converted Jew, originally Herz Marcus by name, who was born in 1727 in Vlotho on the Weser and at the age of twenty-eight, during his service as a carbineer in the infantry of Count Wilhelm of Schaumberg-Lippe, was baptized in the court church of Bückeburg before a large congregation under the new name of Christian Accum. This conversion was no doubt largely the result of romantic motives, for only a few months after his baptism the convert married a young woman of noble Huguenot descent, Judith Susanne Marthe Bert La Motte. She was born in 1732, the daughter of a hat- and stocking-maker, Bert La Motte,

and his wife Jeanne Fauville. This Bert La Motte, the son of a Huguenot captain who had fled from France during the persecutions of the French Protestants, inherited from his father a house and lot at 141 School Street, Bückeburg. This house, which is still standing, went with the hand of Judith La Motte into the possession of the carbineer, Christian Accum, who shortly after his marriage obtained his military discharge and began at his home the business of merchant and soap-boiler.

It was not, however, until nine years after his marriage that Christian Accum took the final step which established him as a recognized citizen of Bückeburg. In the *Bürgerbuch* of this city under the date of February 22, 1764, appears the following entry:

> Christian Accum, who several years previously changed from Judaism to the Reformed Religion, who shortly afterwards married the daughter of the widow of a French refugee, and who until now has worked at the occupation of store-keeper on a Chancery concession, appeared today to take out his citizenship. The rights of citizenship were conferred upon him, for himself, his wife Judith La Motte, and their two children, Philip Ernst and Henriette Charlotte, for two and one half pistoles and the citizens' oath was taken by them in the customary manner.

Seven children were born in the ancestral home of the La Mottes to Christian and Judith Accum but of these only three reached maturity. Two of the children were carried off at a tender age by an epidemic of smallpox which raged in Bückeburg in the spring of 1767. It was just two years after this unhappy event that the sixth child, Friedrich Christian, was born, his baptism taking place on April 2, 1769, in the Reformed Church.

On May 9, 1772, the father, Christian Accum, passed away and the bereaved mother was left with the care and support of four children, the eldest Philip, a boy of thirteen, and the youngest Ernestine, an infant of only eight months. The latter died in her fifth year. It can be seen from these events that the childhood of the future chemist was marked by sorrow and affliction.

The widow, Judith Accum, gave due attention to the religious training and education of her children. Young Friedrich was confirmed on March 13, 1783, and remained in Bückeburg until the completion of his studies at the local gymnasium. This institution, which had been reorganized about 1780 by the ruling count, Philip Ernst, was regarded, according to the standing of schools at that time, as a model of its kind. Several distinguished men were its rectors during the attendance of young Accum. The first of these was Professor Jacob Struve, an eminent scholar and mathematician and father of the famous astronomer, F. G. W. Struve. He was succeeded in 1784 by the learned Samuel Wahl who was called in 1788 to the University of Halle as professor of oriental languages. The last rector under whom Accum studied was Prof. Benzler who was head of the Bückeburg Gymnasium until 1807.

The gymnasium during Accum's student days comprised five classes, of which the three upper constituted the gymnasium proper and the two lower the elementary preparatory course. According to the program of the studies for the year 1787, when Accum was probably in the first grade, or Prima, there were taught in the upper classes during 30 hours per week—Homer, Herodotus, Cicero, Tacitus, Horace, Vergil, Greek and Roman archaeology, logic and metaphysics, literature, world history, geography, rhetoric, Latin and German philology, Hebrew and Syrian dogmatics in connection with the letters of St. Paul, drawing and mathematics. French and English were taught privately. Of the various teachers of these subjects, there was one who was brought into close personal relationship with the Accum family. This was Wilhelm Strack, professor of painting and drawing, who in 1787 married Friedrich Accum's only surviving sister, Wilhelmina.

The Prima course at the Bückeburg Gymnasium required two years for its completion. The curriculum just given was of the old classical type, excellent for the training of clergymen, historians, and philologists but most deficient in those scientific studies which young Accum needed in the preparation for his future career of chemist. This, however, was a universal fault in the educational systems of that time. It was not until many years later that the sciences began to find a place in the program of studies at the higher schools of learning.

But whatever the practical deficiencies of his schooling may have been, there can be no doubt that the active, inquisitive mind of Accum became interested in science at an early date. As a child he was a frequent spectator of the family operations of soap manufacture, to which business his brother Philip afterwards succeeded, and this may have given the young student his first inclination to chemical pursuits. Interested friends of the family may also have exerted an influence. Among these was a prominent physician of Bückeburg, Dr. Bernhard C. Faust, celebrated for his famous "Health Catechism," which was translated into many European languages and for his numerous popular medical writings. It was he who in later years took a prominent part in introducing Dr. Jenner's method of vaccination for smallpox. Dr. Faust's interest in him may possibly have been the cause of Accum's taking up the study of pharmacy after his graduation from the gymnasium.

Previous to 1800 the laboratory of a drug shop was almost the only place where a practical knowledge of the operations of chemistry could be obtained. But in what establishment or under whose guidance young Accum served his first apprenticeship it has been impossible to determine. We only know that shortly after leaving Bückeburg he became associated with certain members of the Brande family who, as apothecaries to George the Third, King of Hanover and Great Britain, operated drug and chemical

establishments in both Hanover and London. It was to the latter city that Accum moved from Germany in 1793 to work as an assistant in the laboratory of the Brande Pharmacy* in Arlington Street, his profession, according to a record in the register of the Alien Office for that year, being stated as that of chemist. He remained in this position for a number of years, devoting his leisure to study and to the attendance of chemical lectures at the anatomical theater in Windmill Street and elsewhere.

It was during this period that Accum attracted the attention of that eminent physician and scientist, Dr. Anthony Carlisle, who took a great interest in the enterprising young foreigner and exerted himself in no small degree towards the advancement of his fortunes. Carlisle was associated about this time with William Nicholson, a versatile, gifted chemist, in collaboration with whom the classic experiment upon the decomposition of water by means of the electric current was performed. Accum may possibly have assisted in this experiment to which in after years he was fond of referring. Nicholson also took a liking to Accum, upon whom he exercised a strong influence and whom he imbued with his own habits of reckless zeal and industry. In addition to other activities, Nicholson was a writer of books upon chemistry, although some of his works, it must be confessed, consist mostly of compilations clipped or translated from the volumes of others. For his assistance in this sort of hack-writing Accum became very useful to Nicholson, who in return did everything possible to promote the interests of his young associate.

In 1797 Nicholson began his famous "Journal of Natural Philosophy, Chemistry and the Arts," more generally known as "Nicholson's Journal," and among the most frequent of his early contributors was Fredrick Accum, who, thoroughly anglicized, no longer used his baptismal name of Friedrich.

The first contribution of Accum to Nicholson's Journal was in April, 1798, upon "The Light Emitted by Supersaturated Borate of Soda or Common Borax," when rubbed or struck in the dark. In the following month is an article, "On the Separation of Argillaceous Earth from Magnesia," by means of ammonia in muriatic acid solution. "The argillaceous earth is totally precipitated and the magnesia remaining in solution may then be separated by adding a solution of pure potash or soda." The method is interesting as it formed the basis of a subsequent process for separating aluminum and magnesium.

In June, 1798, Accum began a series of important contributions entitled, "An Attempt to Discover the Genuineness and Purity of Drugs and Medicinal Preparations." He calls attention to the prevalence of adulteration and to the dexterity with which it is practised so that "not only the mere merchant and drug-broker but even the man of skill is sometimes deceived."

* The proprietor was father of the celebrated chemist, William Thomas Brande, who obtained his first training in chemistry at this same pharmacy.

The inadequacy of the methods described in the Pharmacopoeias is pointed out and improvements are suggested for testing the purity of the common mineral acids, vinegar, "acid of amber," "acid of benzoin," and other preparations. This was Accum's first contribution to a subject in which he was later to rank as the foremost chemist of his time.

It is interesting to read those early volumes of Nicholson's Journal which contain papers by Cavendish, Priestley, Rumford, Proust, Dalton, Davy, Kirwan, Henry, Thomson, Cruickshank, and other celebrities. The coterie of chemists in London at that time formed a most singular group. Nicholson, at a later date, in speaking of his fellow scientists of this period says: "We were in the midst of a war unprecedented for its objects, its extent, and the activity with which it was carried on. It was not a detached body of warriors by profession which fought while the ordinary intercourses of society were suffered to proceed. Every individual was in some measure engaged. Communications were almost totally interrupted; and the sciences, which give life to civilization and afford the only solid assurance that the world shall never again relapse into barbarism, were confined to a few whose habits, situations, or circumstances kept them at a distance from the convulsions and distresses of the times." The hopeful author of these words would have realized the futility of this assurance could he have looked ahead one hundred years and foreseen the terrible relapse into barbarism which the misapplications of chemistry have only recently brought about.

In 1799 there appeared in the September and October numbers of Nicholson's Journal a translation of Achard's classic report on the sugar-beet and its utilization for sugar manufacture. Great interest was aroused in this report and it is significant that, shortly after its publication, Accum obtained from Germany some samples of the new sugar which he presented to Nicholson. As this was the first beet-sugar ever brought from Germany to England, Nicholson's report upon the subject has more than a passing interest. In his magazine for January, 1800, he writes as follows:

> Mr. Accum has presented me with samples of beet-sugar received from Berlin where, I understand, it is now very commonly manufactured. The written account of the culture, produce, and cheapness received at the same time, appearing to want some corrections, I shall only state at present that the samples were (1) a brown or pale straw coloured sugar, in lumps or agglutinated grains, forming a coarse dry powder. It is not very sweet and has a peculiar though not strong smell, which I think resembles that of some articles of confectionery consisting of sugar and flour heated or fried together. Of this sugar the beet is stated to afford five per cent of its weight, leaving a pulp which is an excellent food for cattle. (2) A refined sugar, in very small crystalline grains, forming a powder of which the particles are slightly disposed to adhere and which, when laid upon writing paper, has very nearly the same whiteness. I could not ascertain the figure of any of the grains under a deep magnifier, as most of them seemed to be partly rounded. It has no foreign smell or taste. Equal weights of this and of good loaf sugar were separately dissolved in equal weights of water; and six out of seven gentlemen, who

were present, and tasted the solutions without knowing which was the beet-sugar, determined that the solution of this last was the sweetest. I was among those who thought so; but it appeared to me that its flavour resembled a coarser sugar than that against which it was tried. From this notion I afterwards took two wine glasses of water, and sweetened the one with beet-sugar, and the other with loaf sugar, with the addition of a small proportion of fine moist sugar. When the tastes resembled each other as nearly as I could bring them, I submitted them to the judgment of the company present who, from the irregularity of their conjectures, did not seem to find any notable difference. And when I myself again took up the glasses without noticing the distinctive marks, and endeavored by the taste to determine which was the beet-sugar, it happened that I was mistaken in my decision. This refined sugar seems, therefore, to be of considerable purity and strength. It is obtained from the other sugar, in the quantity of 55 per cent, together with 25 per cent of residual syrup or molasses. (3) The other article was a bottle of this molasses. It is sweet with a singular vegetable flavour, rather fragrant, and would, I doubt not, afford either a pleasant vinous liquor by fermentation or a considerable quantity of ardent spirit.

It is a long step from these few ounces of beet sugar which Accum introduced into England from Germany in 1800 to the 750,000 tons which Germany exported to England in 1900.

Chapter II

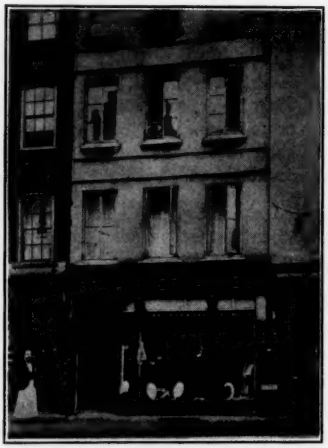
Merchant, Analyst, Lecturer, Teacher, and Popularizer of Chemistry

About the beginning of 1800, Accum moved from 17 Haymarket to 11 Old Compton Street, Soho, where he equipped a laboratory and established the business which was to engage his attention for the next 20 years. Accum's establishment, in addition to being a laboratory for the analysis and examination of commercial products, was also a supply-house for apparatus and fine chemicals. It was an ideal situation for such a business as Soho was then the center of the scientific activities of London. Old Compton Street was not far distant from the Royal Institution of Albemarle Street while close at hand in Soho Square were the residences of William Nicholson and of Sir Joseph Banks, whose homes were frequented by the leading scientists of the day.

His laboratory and chemical supply-house having been well started, Accum's next step was to broaden the field of his establishment by converting it into a school. He gave private lectures to students in experimental chemistry and also took resident pupils who worked in his laboratory under personal supervision. It was a strange medley of activities which Accum had under way, but diversification was the strong point of nearly all the London chemists one hundred years ago and there seems to have been no discordant clashing of interests. The readiness of Accum to satisfy all the intellectual and material wants of chemists was announced upon his business cards and letter heads as follows:

Mr. Accum acquaints the Patrons and Amateurs of Chemistry that he continues to give private Courses of Lectures on Operative and Philosophical Chemistry, Practical

Pharmacy and the Art of Analysis, as well as to take Resident Pupils in his House, and that he keeps constantly on sale in as pure a state as possible, all the Re-Agents and Articles of Research made use of in Experimental Chemistry, together with a complete Collection of Chemical Apparatus and Instruments calculated to Suit the convenience of different Purchasers. Philosophical Gentlemen residing in the Country or Abroad, desirous of becoming purchasers of large or small Collections of Chemical Preparations, etc., may have explanatory Lists previously made out agreeably to the Expense they are willing to incur, and Chemical Catalogues may be had at the Laboratory, Old Compton Street, Soho, London.



The building in Old Compton Street where Accum had his Chemical Supply House, Laboratory and School from 1800 to 1821. It was in this Laboratory that the first American students (Benj. Silliman, William Peck, James Dana, and others), who went to Europe early in the nineteenth century to study chemistry, obtained instruction. The original number of this building was changed from 11 to 33 Old Compton Street, in 1896. (From a photograph by James P. Ogilvie of London.)

In 1801 Accum was appointed chemical operator at the Royal Institution where he collaborated with Davy, who had just been appointed to the lectureship. Accum's manipulative skill and ingenuity in the construction of apparatus were well known before this time and his display of these talents before the fashionable audiences at the Royal Institution, during the few years in which he acted as operator, was very favorably commented upon. The following year Accum came forward as a public lecturer upon chemistry and mineralogy. His first courses in these subjects were given in a small lecture-room at his laboratory. The number of his auditors, however, increased so rapidly that he was soon obliged to find a more capacious hall and for a considerable time he delivered his public lectures at Dr. Hooper's Medical Theater in Cork Street.

The growing reputation of Accum as a teacher and lecturer finally led to his appointment, early in the year 1809, as Professor of Chemistry in the Surrey Institution at Blackfriar's Bridge, and here he continued to give lectures on chemistry, mineralogy, and pharmacy during the remaining years of his residence in London.

His lectures became very popular with the London public and drew large audiences of both young and old. In a contemporary print of the period by Rowlandson, Accum is shown performing experiments before a class of both sexes in the lecture hall of the Surrey Institution. Wonder

and interest are expressed upon the faces of the stylishly dressed audience, some of whom are caricatured in a ridiculous way. One old enthusiast, who watches the experimenter with his head and hands resting upon a cane, has a book marked "Accum's Lectures" thrust into his side pocket.

Accum has left some very clearly defined views upon the teaching of chemistry. He was fond of stating that the proofs of chemistry were grounded upon an appeal to the senses and, acting upon this principle, he made experiment the basis of his method of instruction. In the presentation of his experiments, Accum took the very sensible view that the

CHEMICAL LECTURES.

A cartoon by T. Rowlandson of Accum giving a chemical lecture before an audience at the Surry Institution of London. The old man in the lower left-hand corner has a copy of "Accum's Lectures" projecting from his coat pocket.

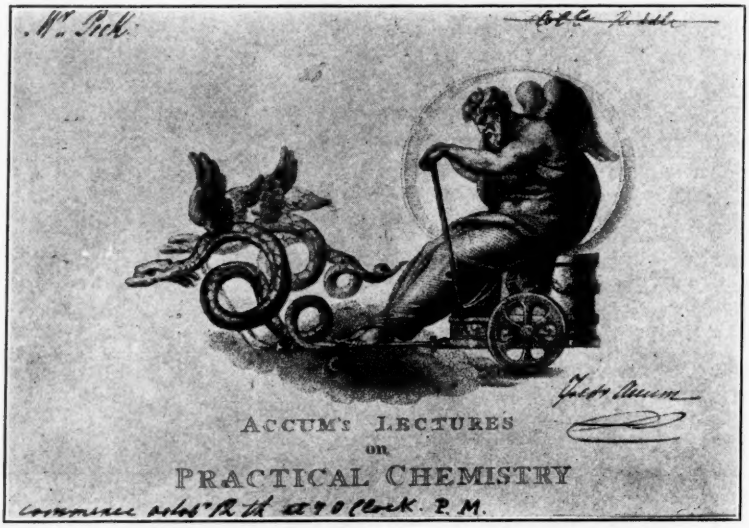
simplest possible means was the best and that anything beyond the actual need of apparatus was an encumbrance. He ridiculed "the frivolous regard to show which characterised so many public lectures."

"Many chemical phenomena," he states, "cannot be accurately observed without the help of instruments calculated to assist the imperfections of our senses; but it is equally true that many of the brilliant apparatus which are daily displayed in the laboratories of teaching chemists as instruments of research, serve more to divert the attention of the auditors than to elucidate the truths of the science."

In his striving for simplicity, however, Accum was never crude. There

was a certain artistic finish in all that he accomplished, even in matters of detail. A good illustration of this trait is afforded by the little cards which, filled out with the name of the student and signed by Accum, served for admission to his lectures. These cards, which were probably printed at the art establishment of his friend and fellow countryman, Rudolph Ackermann, bear a representation of the god Saturn, the patron of chemistry, seated in his chariot which is borne through the sky by two winged dragons; accompanying the god is the planet which bears his name, with its belt of rings.

The school of chemistry which Accum started in Old Compton Street furnished for years the only laboratory of importance in England where



Card of Admittance to Accum's Lectures on Practical Chemistry. (Used by Prof. William Peck of Harvard College and showing Accum's signature.)

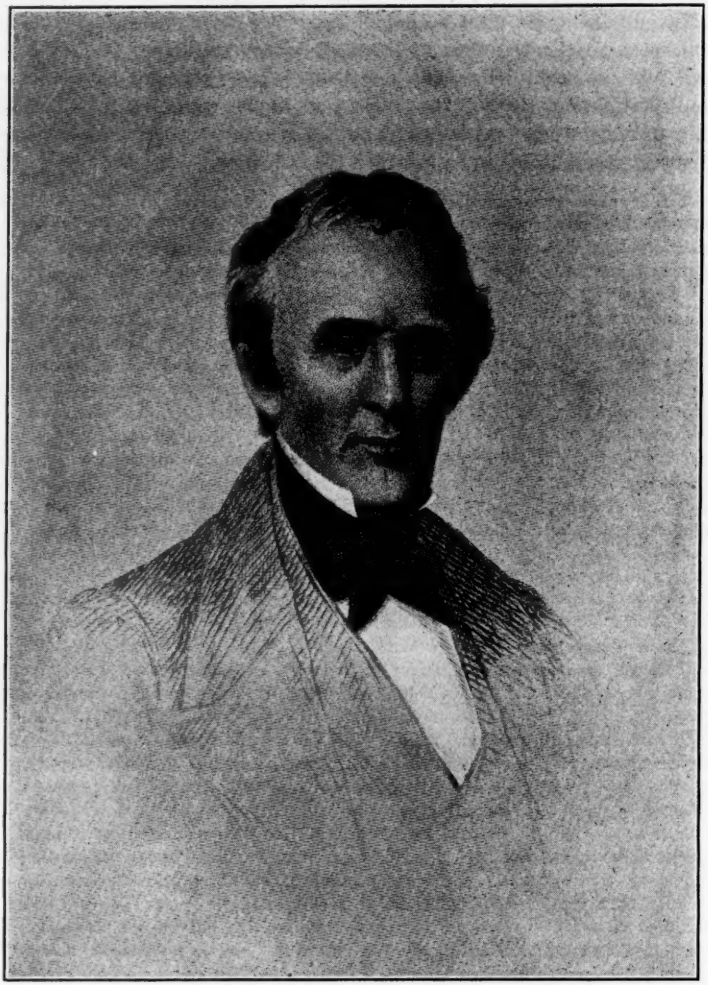
students could obtain a practical knowledge of chemistry. The necessity for practical instruction in chemistry, in addition to the academic knowledge imparted by lectures, was first urged in France by Fourcroy, Rouelle, Vauquelin, and Gay-Lussac; but outside of France there was for many years no place where laboratory instruction in the new theories of chemistry could be obtained. Accum's school of chemistry, which antedated by over twenty years the famous institute of Liebig at Giessen, was an effort to relieve this situation and the attempt was justified, as is shown by the fact that his laboratory was frequented by men in the highest walks of life. Lord Palmerston, Lord Camelford, the Duke of Northumberland,

the Duke of Bedford, Earl Percy, Count Münster Meinhovel, Admiral Sir John Warren and Sir John Sebright were among the prominent men who received instruction there. Accum's laboratory has also the distinction of being the first school of chemistry to which early students went from the United States. Prof. Benjamin Silliman, Sr., of Yale, Prof. William Peck of Harvard, and Prof. James Freeman Dana of Dartmouth are among those to be mentioned in this connection. The elder Silliman, who studied with Accum in the summer of 1805, has left some interesting reminiscences, from which the following is taken.

I early made the acquaintance of a celebrated practical chemist, Fredrick Accum, a German, but fully established in London, and speaking the English language very intelligibly. After frequenting his establishment near Soho Square daily for many weeks, for purposes to be mentioned hereafter, I became satisfied that I could employ him advantageously to obtain for me the desired chemical apparatus. He was well acquainted with practical chemistry, and was much resorted to to make chemical analyses and examinations of many things—he was to the Londoners a pet chemist. He was a most obliging and kind-hearted man; and in ways which I will hereafter mention, as well as in relation to apparatus and preparations, he was always prompt to serve me, and would for that purpose go to the end of London, if not to the end of the earth. He had been, moreover, the operative assistant of Davy in the Royal Institution, and in that way had become familiar with the requirements of philosophical chemistry and class instruction, as well as with the wants of the arts and economics. In his house he kept a considerable variety of apparatus; and his extensive acquaintance with all dealers and manufacturers of instruments enabled him to obtain all that I wanted, better than I could do it myself in the immense world of London, then (the summer of 1805) containing a million people, now (1858) I suppose, two and a half millions. I commissioned him therefore to procure for me all the chemical glass, earthenware retorts and tubes, Black's portable furnace and appendages, and a hundred other things needed in practical and philosophical chemistry, my own experience in Philadelphia and in Yale College as well as since my residence in London having made me now a competent judge and Accum himself added the results of his own experience in the Royal Institution under Davy as well as in the practical arts.

Before coming to England I made myself familiar, in a good degree, with popular chemistry, and having a natural tact for manipulations, I was already a pretty expert experimenter. I wished, however, to become acquainted with difficult processes and I therefore engaged Mr. Accum to give me private instructions, and to devote some hour or hours to me daily in his working laboratory. He then requested me to name the subjects with which I was least acquainted, or not acquainted at all, and to them we devoted our time and efforts. Among the subjects were the analysis of ores, the formation of the crystallized vegetable acids, the arsenical compounds, etc. We operated upon arsenious acid, white arsenic, by nitrate of potassa in a hot crucible, for the purpose of turning it into arsenical acid. Mr. Accum did not caution me against inhaling the fumes which were floating about the room, and, indeed, without a caution from him, I ought to have been on my guard, as I very well knew these fumes to be poisonous; but our minds were so much engaged that we neglected our safety. We both suffered serious inconvenience for some days in prostrated muscular power, and in debility and derangement of the digestive organs. The time passed in this manner with Mr. Accum was, in general, profitably spent; sometimes we were engaged together a whole morning. He would receive no compensation for his time, his reagents, and his services—the only

instance of the kind that I met with anywhere at home or abroad during my novitiate. Eventually, however, Mr. Accum received compensation indirectly by the very considerable order which he executed for Yale College.



Professor Benjamin Silliman of Yale University as a young man. (Silliman studied under Accum in 1805.)

I showed to him a pair of copper concave mirrors, silver plated, which Mr. Banks had constructed for me to show the reflection of heat. He remarked that he wished to obtain such a pair of mirrors but that if he ordered them in his own name, of Mr. Banks,

he might not obtain them in a year, as the manufacturers of philosophical apparatus were wont to be dilatory especially in the execution of domestic orders as they wished to obtain foreign orders. He desired me, therefore, to obtain another pair of mirrors of Banks without naming him. I procured them accordingly, and I believe he expected to pay for them. It seemed to me, however, that as he had devoted so much time to me and treated me liberally, it would be but fair and honorable to make him welcome to the mirrors and I presented them to him accordingly.

Accum was afterwards instrumental in introducing young Silliman to Sir Humphrey Davy and was of great service to him in other ways.

Among other practical exercises which Silliman performed under Accum's direction during his residence in London was the preparation of oxalic acid. He states that he obtained, by treating $^1/_2$ lb. of white sugar with $3^1/_4$ lbs. of aqua fortis, $4^1/_2$ oz. of oxalic acid, at a cost for materials of 2 shillings per ounce. Accum seems to have granted his students the complete freedom of his laboratory from basement to roof. Silliman writes, in his "Elements of Chemistry," of seeing the light, which lime from Carrara marble gave off when slaking in the cellar of Accum's house, and again of finding a gigantic crystal of citric acid in a forgotten solution in the garret of the same building. Such observations, at the present day, may appear trivial and commonplace, but if so the fault is ours. The relish for scientific studies and scientific forms of amusement is said to have been stronger one hundred years ago than it is at present.

The liberality of Accum, to which Silliman refers, is confirmed by the testimony of another American student, Prof. William Peck, in the report of his European studies to "The Honorable, the President of the Board of Visitors" of Harvard College, dated Boston, June 11, 1808.

Having taken a rapid view of these and some other objects which Oxford presents, I hastened back to London to attend a course of chemical lectures, of which the analysis of minerals formed a part. The lecturer, Mr. Accum, would not receive any compensation, tho' I pressed him to accept it.

Such examples of free instruction, as those narrated by Silliman and Peck, were probably exceptional for Accum had fixed charges for all his courses of instruction, as may be seen from the following prospectus for the year 1812.

Operative Chemistry: A course of private demonstrations on operative chemistry, comprehending a summary exposition of the practical processes and operations of the chemical laboratory, 30 lectures—27 guineas. The same course on a more extended plan, 50 lectures—39 guineas.

Mineralogy: A course of private demonstrations on mineralogy, elucidating the art of analysing minerals, the practical methods of examining them by chemical agencies and general facts relating to mineralogical science. 36 lectures—34 guineas. The same course, more extended, including the theory of crystallography, after the method of Haüy, etc., 50 lectures—39 guineas.

Technical Chemistry: Elucidating the theory of the individual processes and sum-

mary philosophical principles on which the chemical arts and manufactures are established and upon which depend their successful practice and improvement. 24 lectures—29 guineas.

House pupil—per annum 160 guineas.

If accommodated with board and lodging in the house, per annum 260 guineas.

The reference which Silliman makes to ordering chemical supplies for Yale College is an indication of what other American institutions were doing at that time. Several of the first college laboratories in the United States were fitted up by Accum. If any one should take the trouble to examine the correspondence of the older colleges between the years 1802 and 1820, he would almost certainly meet with one of Accum's bills. It is interesting to compare the prices of these old accounts with those of today. One such bill, which has come into the author's possession, made out to Professor Peck of Harvard, is as follows:

London, Compton Street, Soho, Apr. 14, 1808

Professor Peck

Bo^t of FREDRICK ACCUM AND ALEXANDER GARDEN

Experimental Chemists.

		£	s	d
1/2 oz.	Litmus		–	2
1/4 oz.	Pure Barytes		1	–
1/4 oz.	Pure Strontia		1	6
1 oz.	Sulphuret of Lime		–	9
1/2 oz.	Oxalic acid		1	3
1/2 oz.	Oxalate of Ammonia		1	3
2 oz.	Carbonate of Ammonia		1	–
2 oz.	" " Soda		1	–
2 oz.	" " Potash		1	–
1 drm.	Succinic Acid		1	–
1/4 oz.	Muriate of Gold		1	9
3/4 oz.	" " Tin		–	6
1/2 oz.	Nitrate of Silver		1	3
1/2 oz.	Prussiate of Potash		–	6
1/2 oz.	Pan Potash		1	–
3/4 oz.	Muriate Platina		–	9
2-1/2 oz.	Liquid Ammonia		1	3
1 drm.	Glacial Acid of Phosphorus		1	6
1 oz.	Black Flux		–	6
1 oz.	White "		–	6
1/2 oz.	Phosphate Soda and Ammonia		1	–
1/2 oz.	Muriate of Cobalt		1	3
1/2 oz.	Phosphuret of Lime		3	–
1	Fusible Spoon		–	6
2 bottles	Silvering Powder		2	–
1/2 oz.	Nitrate Strontia		1	6
1/2 oz.	Boracic Acid		–	6

		£	s	d
1/2 oz.	Nitrate Copper		–	6
1 oz.	Lycopodium		1	–
1/4 oz.	Nickel		–	4
1/4 oz.	Bismuth		3	–
	Zinc Wire		–	3
	Platina Wires		3	–
1/2 oz.	Pure Platina in slips		4	–
1 drm.	Ore of Iridium		2	–
1 oz.	Pure Potash		3	–
1/2 oz.	Pure Soda		1	6
1/2 oz.	Phosphorus		4	–
1/2 oz.	Carbonate Barytes		1	6
1 oz.	Naphtha		2	–
1 oz.	"		1	–
3 oz.	Putty Powder		–	9
3-1/2 oz.	Carbonate Strontia		4	–
1. 1/2 pt.	Receiver and Retort, grd. & stop.		6	6
2. 1/2 pt.	Retorts plain		3	–
1. 1/2 pt.	Receiver plain		1	6
2. 1 pt.	Retorts		4	–
1. 1 pt.	Receiver		2	2
2	Wedgewood Retorts		3	–
2	Earthenware "		4	6
1	Iron Retort		13	–
1	Flexible conducting tube		6	6
1	Retort Funnel		2	6
2	Glass Funnels		2	–
1	Wedgewood Mortar and pestle		2	6
1 lot	Glass Tubing		3	6
2	Subliming Pots		1	–
1	Nest of Crucibles		1	–
3	Crucible Stands		1	–
2	Muffles		4	6
2	Calcining Pans		1	–
1 pair	Crucible Tongs		3	–
1 pair	" " bent		3	3
1	Portable Universal Furnace with Sandbath, Circular Iron Rings, etc., complete	6	6	–
32	Vials in sizes		5	9
4.1/2	Stoppers in sizes		2	8
1	Strong Packing Case	1	5	6
1	Platina Blowpipe spoon		7	–
5	small vials filled with alcohol		1	8
1	" " of Ipecacuanha		–	8
2 oz.	Paregoric Elexir		1	–
1/2 oz.	Laudanum & vial		–	8
2 oz.	Magnesia & bottle		1	–
			–	–
		£ 15	2	4

The average price of the laboratory chemicals upon this bill is about three times what it is at present; whereas platinum in 1808, owing to the limited demand, cost only one-thirtieth as much as in 1921.

Accum's preparations of chemicals formed the nucleus of several of the early chemical museums in the colleges of the United States. Benjamin Silliman, writing in 1858, speaks of the formation of one such collection for Yale College.

> On my return from the West of England in September, 1805, I found that Accum had already fitted up, in a complete and beautiful manner, a large assortment of chemical preparations. They were salts, acids, metals, combustibles, and compounds of various kinds such as are needed in the illustrations of chemical lectures. They were very neatly put up in short wide mouthed bottles of moderate dimensions—furnished with glass ground stoppers—capped with leather and labelled. I perceived at once that they exactly met my wants and would save me a world of trouble and I took them. They were in subsequent years, exhibited as specimens and were not intended for consumption. To this day I believe most of them are in existence, with of course large additions of substances discovered since and new preparations.

These old museum preparations, which were kept in the Chemical Laboratory at Yale University for so many years, have long ago disappeared.

The loss which early importers of apparatus in this country suffered from breakage, as a result of careless handling and packing, has a certain interest. The three records which the author has seen of chemical glassware received by early college laboratories in this country from Accum all make mention of breakage. On Prof. Peck's bill previously quoted, three small items were marked as received in bad condition. Prof. Silliman was less fortunate.

In the summer of 1805, during his visit to the mines of Cornwall in the west of England, Silliman had left instructions with Accum to collect and pack apparatus. On his return in September he found the cases ready for shipment but the packing had been carelessly performed. Glass vessels had been laid upon their sides and, sawdust having been poured in, a small boy was engaged to tramp the packing material into the cracks and interstices.

> Accum (writes Silliman) told me evidently with some self-complacency of the *thorough* manner, as he regarded it, in which the packing had been done. I approved all except the incubus of the tramping boy, and I greatly feared what I *might*, and eventually *did*, find.
>
> After my return, on removing the corner of a very large wooden case of apparatus containing the glass which was packed in sawdust, I found a considerable number of the instruments broken, particularly glass air jars and bells for gases. Those glasses that stood vertically and presented a convex dome or arch upward, usually stronger and thicker too in that part, sustained the pressure and were sound, but those that lay on their sides were often broken.
>
> The bill had, however, been paid before I left London and as Accum intended well

and had every inducement to have the glass arrive safely, I made no noise about the matter—but in merchant's style set it down to profit and loss. The loss, however, was not great and a few dollars or at the utmost a few guineas would replace the broken glass.

Silliman remarks that this was the only loss that was sustained in all his transactions for Yale College.

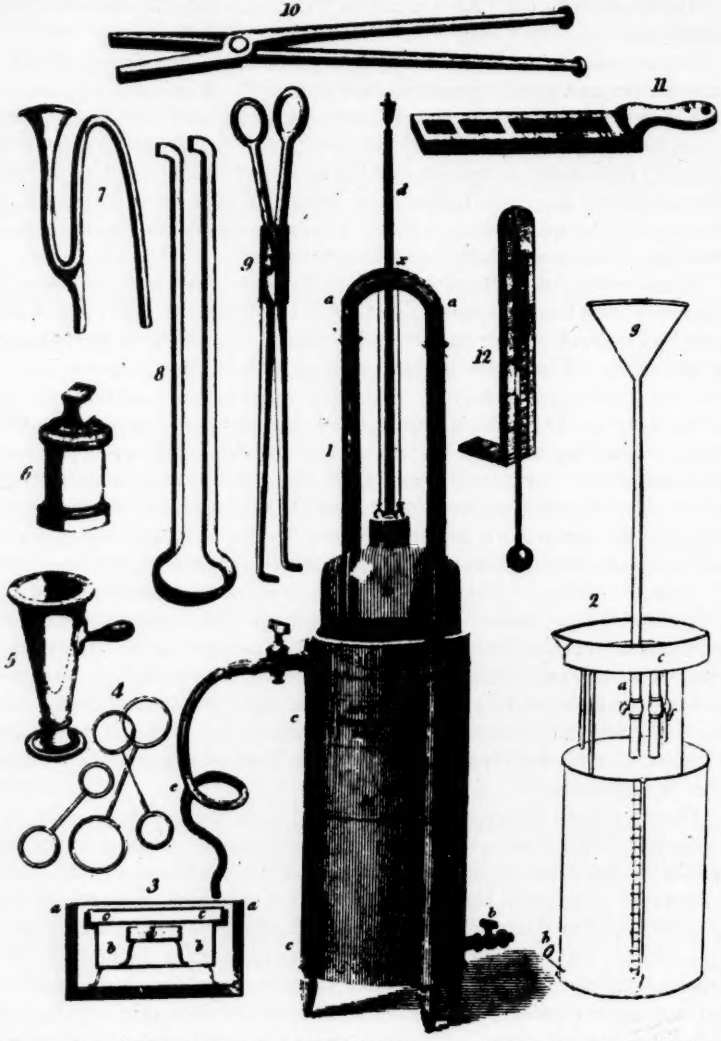
As a manufacturer of new and improved chemical apparatus, Accum's name was for many years almost a household word. His instinctive knowledge of what was best suited for lecture purposes gave him a great advantage over other manufacturers in this respect. A number of our present everyday conveniences in apparatus can be traced directly back to Accum. Scarcely a year passed but what he brought out some new contrivance in the way of a lamp, a drying oven, or a furnace. Accum's gasometer and pneumatic trough were in demand for fifty years.

Accum always encouraged the study of chemistry by amateurs and with this end in view labored constantly to dispel the opinion that an expensively equipped laboratory was necessary for performing chemical experiments or analyses. "Experience has shown," he writes, "that however varied the objects of research may be, and however numerous and different the products to be obtained may appear, the operator is now enabled to perform, at a trifling expense, his processes in the closet with more precision and perspicuity than could formerly be done in the regular laboratory fitted up with costly instruments." For the convenience of home operators, and also as an extra item of business, Accum designed various chemical chests, recreation cabinets, and portable laboratories which he offered for sale, according to the size of the equipment, at prices ranging from £3 to £80. There were also agricultural chests for enabling farmers to perform the chemical examination of soils, manures, marls, limestones, etc. His traveling chests, which were used by mineralogists and prospectors, were so constructed that when the apparatus and reagents were packed away and the drawers and cover locked they could be overturned without injury to the contents. Accum was the first to introduce portable, chemical laboratories.

That a charge of commercialism should have been brought against a chemistry teacher who was also a tradesman was perhaps inevitable. While Accum realized fully the distinction between science and trade, he granted them equal claims and his love for chemistry was coupled with a shrewd, and no doubt inherited taste for business which he made no effort to conceal. But this combination of interests had certain unpleasant consequences and Accum, however amiable and accommodating he might be as a teacher and popularizer of chemistry, acquired at times the reputation of driving a sharp bargain. Silliman relates that, while he had no reasons for believing that Accum ever abused his own confidence in business trans-

actions, he observed one incident that did not impress him altogether favorably.

Coming to the laboratory one day I found Accum laughing and in high glee on account of a good bargain he had made with Mr. Pitt, the Prime Minister, for govern-



Gasometer and other apparatus supplied by Accum for instruction and technical use.

ment. Mr. Pitt, he said, had ordered a large quantity of chemical apparatus for a place in my country. "Ah!" I replied, "What is the name of the place?" "Pondicherry," he replied. "Pondicherry, indeed! That is not in my country; it is in India, at our antipodes; and, moreover, Mr. Pitt would not send apparatus to my country." "But, no matter," he said, "I have taken this opportunity to sweep my garrets of all my old apparatus and odds and ends that had been accumulating for years, and have turned everything over to government." Well, thought I, Mr. Pitt is not here to look after his apparatus and if he were present he would probably not be a very good judge; but I am here and shall keep a sharp lookout for my own concerns.

Accum's own opinion of his double vocation of scientist and tradesman is very naïvely expressed in a letter to Nicholson's Journal, in which he calls the editor's attention to his new crystal models:

> I would submit to your consideration, Sir, that he who establishes a place of fabrication or deposit of an article of use to the sciences, which could not before be purchased, is a benefactor to the public; and under this point of view I offer you the present notice, as a piece of scientific news, though it is likewise of a private commercial nature. I have, with considerable expense and attention, prepared a set of models of crystals, partly solid and partly dissected; and have made arrangements which enable me to supply the public. The dissected crystals are so constructed that they can readily be taken to pieces and built up again in various ways.
>
> A single glance at the dissected models will enable the student to comprehend why crystals are always rectilinear bodies, bounded by planes, and whence that immense variety of crystalline forms is derived with which the mineral kingdom has astonished the world.
>
> As the series of solids to be finished on the present occasion will be limited, such individuals who are desirous of receiving sets of them will have the goodness to favour the author with their orders, either in a direct way or through the medium of their booksellers.
>
> This condition is essential because the author presumes he would otherwise employ his time and labours with more advantage to himself and the public. Further information may be had at the laboratory where several thousand models, both solid and dissected, are ready for inspection.

These crystal models, as Accum intimates, were the first ever placed upon the market.

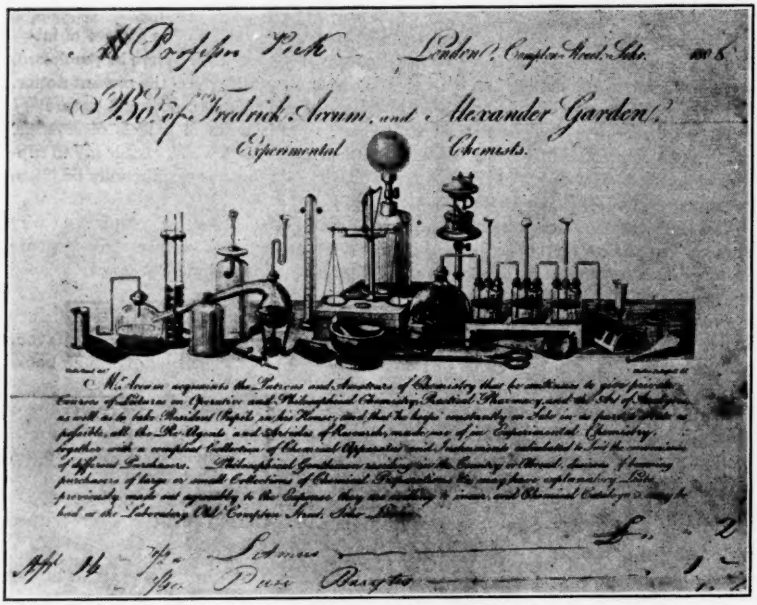
From one point of view Accum's apparatus and chemical business can be regarded only as an important connecting link in a group of closely interrelated remunerative activities. In his lectures and books upon chemistry, pharmacy, mineralogy, and crystallography, he outlined experiments for which he advertised to supply the necessary chemicals, apparatus, specimens, and models, at reasonable prices. The activities of lecturer, author, analyst, industrial chemist, and merchant thus supplemented one another and worked together to the mutual common advantage, all of them, through Accum's clever management, bringing financial grist to his mill. In the whole history of chemistry there is no one who has attempted to discharge so many of its different roles as Accum.

The chemical supply house at 11 Old Compton Street was continued

during the remainder of Accum's London residence. Shortly after the business was started, Alexander Garden, a former student of Accum, joined the firm, but this partnership was dissolved after about ten years when Garden set up an independent establishment at 372 Oxford Street.

While Accum never made any important contributions to the theory of chemistry, he nevertheless accomplished a considerable amount of research, some of which had an important influence upon subsequent developments of the science.

Allusion has been made to some of his early papers in Nicholson's Journal. Among other contributions to this journal may be mentioned a



Bill Head of the Firm of Accum and Garden.

continuation of his studies upon the purity of drugs in April and July, 1800; an historical note upon the antiquity of the art of etching on glass (April, 1800); numerous minor observations, such as the occurrence of benzoic acid in old vanilla pods, etc. (April, 1802); analyses of new minerals, such as the "so-called salt of bitumen, the Bit-Nobin of the Hindoos" (July, 1803), and the Egyptian Heliotropium (October, 1803); and his "Experiments and Observations on the Compound of Sulphur and Phosphorus and the Dangerous Explosions It Makes When Exposed to Heat" (Sept., 1803). The last research attracted considerable attention at the

time and, as it gives a good idea of Accum's technique as an experimenter and of the nature of the practical instruction imparted in his school, the following is quoted from his description:

Half an ounce of phosphorus, cut into pieces the size of a pea, was introduced into a Florence flask, containing about ten ounces of water; one ounce of sulphur broken into fragments of about the same size was added, and the whole placed on a heated sand-bath. In a few minutes the union of the phosphorus and sulphur was effected. On leaving the whole in the heated fluid, for about ten minutes longer, the empty part of the flask became filled with dense white fumes, which increased more and more; being unable to observe what change was taking place, I carefully removed the flask out of the sand bath and agitated the fluid in such a manner that the fused compound of phosphorus and sulphur still remained under the surface of the water. But the instant this was done, the whole exploded in my hand with a tremendous report; the mixture of burning phosphorus was thrown into my face, and occasioned very painful wounds; the pieces of the Florence flask were scattered all over the laboratory, as fine as sand, and the larger parts of the neck of this vessel were driven into my right hand, as well as into the wall, to a considerable depth.

Anxious to understand the nature of this unexpected explosion, I again exposed to heat, in a similar manner, two drachms of phosphorus and half an ounce of coarsely powdered sulphur, in a small flask containing four ounces of water. The mixture, after having been left in a heated sand-bath for about ten minutes, exploded with prodigious violence and a flash of fire rose up to the ceiling. The same experiment was repeated with larger quantities of phosphorus and sulphur, three successive times, with similar effects. These experiments were made at the laboratory and in the presence of the Right Hon. Lord Camelford, who liberally supplied the materials for these and the following experiments, and permitted them to be made on his premises.

Before I advance anything further concerning the accension of this compound, I beg leave to relate one instance more of a similar nature which happened lately in my own laboratory. Mr. Garden, a philosophical gentleman, immersed into a vessel filled with warm water a vial containing six ounces of phosphorus, to which had been previously added one drachm of a mixture of phosphorus and sulphur. The contents of the vial being liquefied (which was the intent of immersing it into heated water) he removed the vial out of the fluid, taking care to close its orifice with his finger, and then agitated it gently. The moment this was begun the vial burst to pieces with a report like a gun, the burning mixture was thrown in all directions and the whole laboratory was filled for some hours with a very dense cloud of white vapours.

Being thus sufficiently convinced of the danger which attends the combination of phosphorus with sulphur, under such circumstances, I introduced into a Wedgwood's tube, closed at one end, two drachms of phosphorus and double that quantity of sulphur. I then added four ounces of water and closed the other extremity of the tube with a cork into which a bended tube was cemented, which terminated under a glass cylinder filled with mercury, standing inverted in a bason containing the same fluid. I then reclined the tube and applied heat to that part which contained the phosphorus and sulphur; on increasing the heat gradually a quantity of gas was collected, which amounted to nearly two quarts. But no explosion took place.

To learn the nature of this gas, I transferred a quantity of it into the water apparatus and agitated it in contact with that fluid for a few minutes. Its volume was now considerably diminished. On repeating the experiment in distilled water, it was found that this fluid absorbed nearly $^1/_4$ of its own bulk. On sending up one part of atmospheric air into a cylinder holding six parts of this gas, an instantaneous inflammation ensued.

the cylinder became filled with white fumes and a white crust lined the inner surface of the glass. Finding thus that the gaseous product was decomposable by atmospheric air, I collected another quantity of gas in a similar manner as before; and mingled it gradually with oxigen gas until no further accension ensued. The gas left behind amounted to $^1/_{64}$ of the whole. It had all the properties of nitrogen gas.

The white flakes which were collected from the sides of the glass cylinder, as well as from the surface of the mercury over which the experiments were made, attracted moisture rapidly and became converted into a cream-like fluid. They consisted of sulphur, sulphuric, and phosphoric acids.

Oxigenized muriatic acid gas* acted more violently than oxigen gas when mingled with this gaseous compound over mercury; the result was a considerable detonation, accompanied with vivid green light and dense white vapours.

From the results of these experiments, it became obvious that the gas under examination was a compound of hydrogen, sulphur, and phosphorus.

The remainder of the article is devoted to a description of the compound of sulfur and phosphorus and contains a suggestion that it might be employed to advantage as an absorbent of oxygen in eudiometry. Accum's elementary analysis of the gaseous product which he obtained was correct. It was afterwards proved, however, that this gas, which he believed to be a compound and which chemists for a time called sulfur phosphoretted hydrogen, was a mixture of hydrogen sulfide and hydrogen phosphide.

The research of Accum, that has just been quoted, relates to a subject about which there still exists considerable uncertainty. It is interesting to know that the constitution and properties of the sulfides of phosphorus are still being investigated by Stock and other chemists.

Accum was a frequent contributor of chemical papers to Tilloch's *Philosophical Magazine*, as well as to Nicholson's Journal. In 1808 he began a series of important contributions to Tilloch's magazine upon the chemical properties and composition of different mineral waters and his papers upon this subject extend over a period of eleven years. The springs of Cheltenham, Middleton Hall, and Thetford were among those which he examined. In this particular branch of chemical analysis, Accum became very proficient and his reports show a great advance over previous investigations of mineral waters. In commenting upon an analysis of Thetford spring made in 1746 by Dr. Manning, Accum makes these observations:

Dr. Manning's analysis displays much chemical knowledge. He determined the most predominant constituent parts of the water with accuracy; but the science of chemistry at the time the analysis was made was not sufficient to enable him to trace their true combinations. For it is particularly in such subjects as these, that the science of modern chemistry claims a precedence over the labors of our predecessors.

Hence the records of the older experimenters must, like all those that have been superseded by a fresh acquisition of knowledge, be consigned to an honourable repose.

* Chlorine, which in 1803 was believed to be an oxygen compound of hydrochloric acid.

This quotation shows that the pride in "modern chemistry" was as strong one hundred years ago as it is today. The analyses of Accum attained long ago the same "honourable repose" as those of his predecessor, Dr. Manning, for they too "have been superseded by a fresh acquisition of knowledge."

In Tilloch's magazine for 1808, Accum published an interesting contribution upon the production of fire by compressed air. He describes an ingenious instrument for igniting tinder and other fibrous substances by the sudden compression of air and suggests that the ignition may be due to other causes than to the heat which is liberated when gases are compressed.

The discovery of iodine by Courtois was announced to the French Institute in 1813 and the attention of chemists everywhere was immediately directed to this new substance. One of the first chemists in England to study the methods of preparing iodine was Accum and we find in Tilloch's magazine for January and February, 1814, two articles by him upon this subject. He calls attention for the first time to the difference in iodine content of the different varieties of kelp and gives detailed instructions for isolating and purifying iodine for lecture room as well as for commercial purposes.

(*To be continued in the November Issue*)

Insulin May Help Gland Regeneration. That the continued use of insulin may really cure and not just allay diabetes by giving the overstrained glands a long rest is the opinion of Dr. F. G. Banting, who first extracted insulin from the pancreatic glands of animals and made it available for use by diabetic patients.

"Regardless of the severity of the disease," said Dr. Banting, "all patients may now be maintained sugar free. Since this is possible it is to be strongly advocated, for we have abundant evidence that there is a regeneration of the islet cells of the pancreatic glands when the strain thrown upon them by high blood sugar is relieved. In some moderately severe cases the carbohydrate tolerance has increased sufficiently so that insulin is no longer necessary."—*Science Service*

Soy Bean Oil Recommended for Use in Enamels. Soy bean oil is not merely a partial substitute for linseed oil, but actually its superior in certain uses, notably in the manufacture of white enamel, according to I. C. Bradley of Bloomington, Illinois, who addressed the sixth annual field meeting of the National Soy Bean Growers' Association. Though rated only as a semi-drying oil in its natural condition, Mr. Bradley states that by heat treatment and the addition of driers it can be made to do much of the work of linseed oil.

Not only are soy beans becoming more valuable as a source of vegetable oil, because of their high oil content, but the oil cake is so rich in protein as to make it even more valuable than the oil itself. Mr. Bradley stated that the money value of this by-product of oil extraction was one-third greater than the value of the main product, a reversal of the usual order of things.

The soy bean is remarkable among the bean tribe in that it contains oil instead of starch. Its oil content averages about 20 per cent, of which about two-thirds can be extracted by commercial methods. The protein content is remarkably high, averaging around 40 per cent.—*Science Service*

THE APPEAL OF SCIENCE TO THE COMMUNITY*

ALEXANDER FINDLAY, UNIVERSITY OF ABERDEEN, SCOTLAND

ALEXANDER FINDLAY

Utility of Science
Applications to Industry
Government Aid in Scientific Research
Price of Industrial Efficiency
Pure and Applied Science
The Scientific Spirit
Cultivation of the Spirit of Science
The Man of Science in the Community
Value of Scientific Knowledge

The subject on which I shall venture to speak to you this evening is one which some of you, perhaps, may deem too threadbare for further consideration. The position which science holds, or ought to hold among the general interests of the community has formed the theme of many an eloquent and vigorous address, and leaders among the men of science, in this and other English-speaking countries have, time and again, urged its claims upon an apparently or supposedly slothful and perverse generation. If I then venture once more to speak on this topic it is because there are abundant evidences that the past few years have been a time of awakening and awakened interest in science, and that it is our duty to do our utmost to guide and quicken this interest. Has not the well-known Scottish writer, Sir James Barrie, borne testimony that "the man of science appears to be the only man who has something to say just now," although he somewhat unkindly adds the opinion that he is the only man who does not know how to say it? Although a great change has, I believe, taken place in public opinion, in this as well as in my own country, regarding the work of science, there nevertheless exists the necessity of urging, with persistence but also with restraint, the great importance of cultivating what we may call the scientific habit of mind and of securing the right and proper appreciation of the value of creative scientific work. We cannot, therefore, consider too carefully or too frequently how, in a spirit of service, we may best frame our appeal to the community and bring to our fellowmen a knowledge and appreciation of those benefits and delights which come from a study of nature.

* Address delivered before various local sections of the A. C. S. during Dr. Findlay's recent tour.

Utility of Science

The ground on which the appeal of science has been most frequently and, perhaps, most noisily made has been that of the utility of science, not merely in the practical business of life and of earning one's livelihood, but also in the preservation of life itself and in the provision of physical comfort. "Real gain, real progress," as the late Sir William Ramsay declared, "consists in learning how better to employ energy, how better to effect its transformation," and, looking back over the history, more especially of the 19th and 20th centuries, down to the present day, it is easy to mark how great have been the achievements of science in this direction. One thinks, for example, of the development of the steam engine, the gas engine, the internal combustion engine; of the development of the electric dynamo and the utilization of electrical energy; of the conversion of the energy of falling water into electrical and other forms of energy; of the development of machinery of all kinds; of the concentration of chemical energy, as in explosives, and so on. And in the domain of biological science and of preventive medicine the achievements have been no less remarkable. It is the biologist and bacteriologist who have made Central Africa, for example, safe for man's habitation, and it is no exaggeration to say that the Panama Canal was built not by the engineer but by the biologist. It is the man of science who, through his influence on industrial and agricultural development and the development of natural resources, determines what population a country can support. It is the man of science, indeed, who in the last resort decides the economic fate of nations.

It was Pasteur who claimed that "in our century, science is the soul of the prosperity of nations and the living source of all progress. What really leads us forward are a few scientific discoveries and their applications." And these claims can, indeed, be substantiated by the work of Pasteur himself.

In the middle of last century, as you all know, the silk cultivation of France, of Spain, and of Italy was threatened with extinction. In 1849 a disease called *pébrine* attacked the silk worms of France and in the short space of twelve years, we are told, "the mulberry plantations on the slopes of the Cevennes mountains, which had for long given employment to a happy and contented people, were completely abandoned, and the once radiant faces of men became sad and melancholy because misery and poverty prevailed where before happiness and plenty had reigned." In the same space of time, also, the annual revenue derived by the State from the silk industries fell from 130,000,000 to 8,000,000 francs. From the bankruptcy with which it was faced, the silk industry was saved by the scientific labors of Pasteur. It is to Pasteur, also, that much of the present-day prosperity of the various fermentation industries is due; it

is to Pasteur that we owe our earliest knowledge of the bacterial origin of disease and the production of immunity by vaccines which led to the culminating glory of Pasteur's life, the cure of rabies or hydrophobia. It is, moreover, on the foundations of Pasteur's work that the practice of antiseptic surgery was built up, whereby the havoc and torture of festering sores and gangrenous wounds were abolished from the surgical wards of our hospitals. What a glorious life of service to humanity for a single man to achieve! How irresistible must seem this appeal of science! And the people not only of France but of other countries as well, answered the appeal and erected the Institut Pasteur as a tribute to the genius of Pasteur and in recognition of the services which science through him had rendered to mankind. The appeal in this case went home because it was centered in a living person whose "science" could be generally understood and whose unselfish work touched the heart and humanity of man. In contrast with the success of that appeal stands the comparative failure of the more general appeal for the support of the science laboratories of France which was made two years ago on the occasion of the national celebration of the hundredth anniversary of Pasteur's birth. The appeal in this case was too general; it awakened small response because the people could not understand its meaning. From this we may learn that even the utilitarian appeal of science will arouse a general response only in so far as it is interpreted to the community in terms which the people can individually understand.

Applications to Industry

And this has been found to be the case, also, with regard to the utility of science in its applications in industry. The different countries of the modern world, and especially the older countries, are becoming more and more industrialized, and however much we may sometimes deplore the fact we must recognize that only by this means can the evergrowing populations of these countries be supported. As the populations grow and as the conditions of life become, through competition, more and more strenuous and exacting, the necessity arises for ever-increasing efficiency in the industries and in the utilization of the natural resources of the country. It is only natural, therefore, that men of science, in a spirit of helpfulness and in the consciousness of their knowledge, should have urged the vital necessity of a wider and fuller application of scientific knowledge and scientific method, for by that means alone was it possible to enlarge the scope of the industries and to increase their efficiency. For a long time the appeal bore little fruit in my own country, and, as I gather, not very much even in this. In this country, the enormous, the apparently almost inexhaustible natural resources of the country, the great and rapidly expanding home market and the absence of any serious competition from

outside, made it difficult for people to realize the wisdom if not the actual necessity for avoidance of waste and for the application of science in industry. And in England, the industries on which, early last century, the country grew wealthy were such that their dependence on science was not very obvious and so, owing to a natural inertia of mind and a fairly widespread prosperity, the necessity of applying more scientific methods with a view to diminishing waste and improving production, and for the purpose, also, of establishing new industries never entered very fully into the tissues of the people's minds. We prided ourselves on being a practical people; abstract learning and knowledge were held in comparatively slight esteem; the investigations of men of science made little appeal to us, for the people did not understand them; the people indeed, had not been educated so as to be able to understand them. While it is easy to place on the manufacturers the responsibility of a general backwardness in applying the discoveries of science to industry, it must be confessed that the teachers of science were not wholly free from blame for failing to enter more fully into the difficulties of the manufacturers and for failing to keep in touch with the industrial and practical life of the country and to show more clearly and convincingly the relation between their own sometimes abstract work in pure science and the practical everyday life of the community.

Government Aid in Scientific Research

If, however, the appeals of science remained largely unheeded in times of prosperity they had perforce to be responded to in the adversity of war. The highest efficiency of manufacture was necessary if the country was to succeed: men of the widest scientific sympathies and of highest eminence in creative science became the directors and controllers of industry, and the least efficient factory had to be brought to the level of the most efficient. It was the demonstration of the increased efficiency produced by scientific control that made the utilitarian appeal of science carry conviction to the manufacturers, which interpreted to the mind of the layman and of the statesman the true relation between the discoveries of pure science and their applications in industry. As a result of the lessons learned during the war, the government of Great Britain in 1919 appropriated the sum of £1,000,000 for the encouragement of scientific and industrial research. Manufacturers were encouraged to group themselves according to their industries and to establish, with the help of government grants, research institutes where the discoveries of science could be focussed and investigations carried out on the problems of each particular industry. Government assistance was promised for a period of five years, after which time, it was hoped the research institutes would have become sufficiently firmly established and would have proved their value so that the industries

themselves would assume the whole burden of their maintenance. Upwards of twenty research institutes have been thus established, and they have proved themselves of the greatest value to the industries. The Department of Scientific and Industrial Research, also instituted or supported the investigation of problems of national importance, such as the economical utilization of coal, including the methods of low temperature carbonization for the supply of a readily-burning coke and of a fuel suitable for internal combustion engines. In this direction, it may be said, great advances have been made in recent years, and it is, perhaps, not too much to hope that the present generation will yet live to see a smokeless Britain freed from the necessity of importing its supplies of motor fuel.

The Department of Scientific and Industrial Research has also sought to encourage the continued supply of adequately trained research workers by awarding scholarships and grants for materials and apparatus to graduates of the universities and to others similarly trained.

The work of the Department was, at first, admittedly only an experiment, but it is now an experiment which has succeeded. The future of the application of science in industry in Great Britain is, I believe, full of hope; and although as a result of industrial depression and for other reasons the wave of enthusiasm for the application of science in industry may recede somewhat from the high water mark of appreciation exhibited at the close of the Great War, there can be no ebbing of the tide to the level of pre-war years.

In the United States, as I am aware, even greater appreciation of the importance of science and of its applications for the material welfare of the people and for the industrial prosperity of the country has been shown by the Federal Government, by the States, and by individual firms; and one cannot fail to be profoundly impressed by the very large pecuniary resources now placed at the disposal of the scientific laboratories of the universities, both by the States and by private munificence, nor can one withhold admiration of the great and ever-swelling stream of new knowledge flowing from these laboratories.

Price of Industrial Efficiency

While, however, we may rejoice that the importance of science in its applications to manufacturing processes and to the general activities of our workaday life has been so largely recognized, let us always bear in mind that the gospel of efficiency while it may bring salvation to our industries will, if carried into action without regard to higher considerations, be productive of great evil to the people and the country. For remember, efficiency calls for organization, and organization demands discipline; but as Sir Arthur Schuster so admirably put it some years ago, "Discipline is not inborn but is acquired by education and training. In an emer-

gency it is essential to success, but if it be made the guiding principle of a nation's activity, it carries dangers with it which are greater than the benefits conferred." The loss of individual freedom, the suppression of the sense of individual responsibility, the destruction of the human values, and the conversion of man into a machine are too great a price to pay for industrial efficiency. From this evil root there can too easily spring the ruthless materialism and lust of power of which recent history has given us an example. No, let us beware of making a god of scientific efficiency; it is enough, as also it is necessary, that we make it one of the articles of our creed.

While the utilitarian appeal of science is at once the easiest to make and at present, perhaps, the most powerful to attract the interest of the community, it will, if pressed too strongly or too exclusively result not in the development but in the decay of science, and will weaken that pursuit of truth and knowledge on which the applications of science depend.

Pure and Applied Science

One often hears people of the present day speak as if pure science and applied science were two quite distinct and independent activities; and the so-called practical man, the man of business not specially trained in science and without the scientific habit of mind, is inclined to despise pure science and to insist that what is wanted is applied science. Now we know, of course, that there are not two sciences but only one science—there is science pure and unqualified, aspiring only to truth and knowledge, and there are the applications of science. There can be no application of science, no application of knowledge unless that science, that knowledge, previously exist. It is necessary to realize, it is necessary that the community shall realize that all the great revolutionary changes in our industrial life, all the great inventions which have so powerfully altered the character of our civilization, have come not as the result of effort to achieve results of immediately utilitarian value, but as the result of a patient and persevering pursuit of knowledge without thought of practical or industrial applications. "These grand innovations" said Cuvier, "are only the facile applications of verities of a superior order, not sought with a practical intent, verities which their authors have pursued for their own sake, impelled solely by an ardor for knowledge. Those who put them in practice could not have discovered them; those who have discovered them had neither the time nor the inclination to pursue them to a practical result." The invention of the electric dynamo, for example, was rendered possible only by the previous discovery of electro-magnetic induction by Faraday; the coal tar dye industry arose not out of an attempt to find some use for the evil-smelling liquid and still less as the result of a conscious effort to prepare from it a dye. The production of mauve did not

come on the demand of the dyers (for who could have conceived the possibility of such a thing), but was the outcome of the purely scientific investigations of Perkin on the constitution of quinine. The X-ray tube also was not the result of a consciously directed effort to discover a means whereby we might, as it were, see through a brick wall, might examine the internal structure of the living body or of the inanimate crystal, but as the result of an investigation into the nature of the electric discharge in gases. And, lastly, the invention of the thermionic valve which has rendered possible the transmission of the spoken word over the length and breadth of the earth, was rendered possible only by the study of the emission of electrons by hot bodies, carried out by men searching only for truth and knowledge. As Prof. Whitehead has said: "Necessity is *not* the mother of invention; knowledge and experiment are its parents." "It is no paradox to say that in our most theoretical moods we may be nearest to our most practical applications." The applications of science to the utilities of our daily life may be the result of many years of laborious searching after knowledge, and although it is now widely, but not sufficiently widely recognized that the rule of thumb is dead and that the rule of science has taken its place, advance can continue to be made, even in the utilitarian domain, only if the people have acquired a faith in the power of science and have become convinced that the acquisition of knowledge, sought for its own sake alone, is the necessary precedent of all great inventions and applications of science.

Over-Emphasis of Utilitarian Appeal

Powerful as the utilitarian appeal of science undoubtedly is, it does not, I believe, and in the highest interests of mankind and of our western civilization I hope never will, make the strongest appeal to the minds of thinking men, or to men whose mental horizon lies beyond that of a purely materialistic existence. The numerous inventions which enter so largely into our modern life, the mechanical appliances and material benefits which have come from the applications more especially of physical and chemical science, affect chiefly the machinery of life, and are not the prime movers of men's actions; and over-emphasis of its utilitarian value may, and I believe does, do harm to the highest interests of science. It is, indeed, all too easy for the cynic to point to science not as the uplifter but as the destroyer of the finer qualities of mankind and to represent the aim of science as purely materialistic. The great danger, I would suggest, which we have to face in all our appeals to the community is that while proclaiming the great achievements of science in the creation of pecuniary gain and material prosperity, we lose sight of the idealism of science and destroy the true sense of values by raising the lower above the higher, the material above the spiritual. The real claim of science to fuller appre-

ciation by the community, the claim which we should seek to urge in all our publicity, activity, and propaganda, yes, and in all our schemes of education in school or university, is the cultural, the spiritual, and the moral importance of science. It is for the idealistic aim and not only for the materialistic purpose of science that we must endeavor to win appreciation. For the community as a whole it is not the acquisition of a knowledge of the facts of science but the becoming imbued with the spirit of science that is of chief importance.

The Scientific Spirit

What, then, is the scientific spirit which we desire that all men should cultivate, and on what grounds can we urge its cultivation? The first great aim of science is the seeking out of truth, the penetration into that unknown land which always we see lying half-veiled in mist beyond the continuously receding boundaries of the known. It is the beckoning finger of the spirit of truth and knowledge that lures the man of science forward. "It is the truth alone," said Scheele, "that we desire to know, and what joy there is in searching it out." It is, then, this desire for truth, the constant urge after truth, as the great German writer, Lessing, put it, that we must hold up as an aspiration to the community.

There are some who have been repelled by science and the scientific method of acquiring knowledge by the belief that science can explain nothing and that all it can do is to accumulate and record facts, the cold facts of science, as one has called them. But this is far from the truth. The recording of facts is one of the tasks of science, one of the steps towards truth, but it is not the whole of science. As Oliver Wendell Holmes said: "There are one-story intellects, two-story intellects, three-story intellects with sky-lights. All fact collectors, who have no aim beyond their facts, are one-story men. Two-story men compare, reason, generalize, using the labours of the fact collectors as well as their own. Three-story men idealize, imagine, predict; their best illumination comes from above, through the sky-light." In these sentences we have summed up for us the steps of advance toward truth by the scientific method, toward the formation of those beliefs according to which, in the physical universe, we act. The universe is not a mere mass of uncoördinated facts and phenomena, but is like a noble edifice, the order and arrangement of whose stones are dominated by one grand idea, born in the mind of the architect. It is the work of the man of science, from partial glimpses illuminated by the light of inspired vision, to discover the divine idea by which the whole universe is ordered. Science, then, takes on a nobler and a higher purpose. As the poet, Alfred Noyes has written:

> ". . . . . *What is all science, then,*
> *But pure religion, seeking everywhere*

The true commandments, and through many forms
The eternal power that binds all worlds in one?
It is man's age-long struggle to draw near
His Maker, learn His thoughts, discern His law—
A boundless task, in whose infinitude,
As in the unfolding light and law of love,
Abides our hope, and our eternal joy."

To the misconception regarding the work of science to which I have alluded is doubtless due the discrimination made by Sir Henry Newbolt between science and poetry. "Science is prose, poetry is imagination." Well, the facts and applications of science are no doubt prose, frequently very romantic prose; they are the results of observation and of reason by which man rises superior to the beasts, and which mark the upward steps of civilization. But they are not the soul and spirit of science. The spirit of science is to be found in the great hypotheses and theories of science which, like poetry, are not the product of reason but of imagination and of inspiration which are superior to reason. For the great hypotheses of science are but attempts to gather within the bounds of a brilliant instant of inspired vision a multitude of experiences and to show the harmony of their parts. As Alfred Noyes again has said, "The great moments of science have an intense human interest and belong essentially to the creative imagination of poetry." In the great work of scientific exploration, in the work

"Of those who searching inward, saw the rocks
Dissolving into the new abyss, and saw
Those planetary systems far within,
Atoms, electrons, whirling on their way
To build and to unbuild our solid world,"

and in the attempts to interpret the order and harmony of the universe, the man of science becomes the poet. Without imagination, the great discoveries of science could not be made. As the late Sir Benjamin Brodie, President of the Royal Society, said: "Physical investigation more than anything besides helps to teach us the actual value and right use of the imagination—of that wondrous faculty which, left to ramble uncontrolled, leads us astray into a wilderness of perplexities and errors, a land of mists and shadows; but which, properly controlled by experience and reflection, becomes the noblest attribute of man; the source of poetic genius, the instrument of discovery in science."

Cultivation of the Spirit of Science

The cultivation of the spirit of science appeals not only to the intellect, but creates also an emotional and aesthetic pleasure and so ministers to

that other side of the mental and spiritual life, the desire for beauty. The aim of science is the pursuit of truth and from the roots of truth springs beauty; and whether the truth be sought in the movements of the heavenly bodies, in the architecture of the molecules or in the grandeur of the subatomic universe, everywhere we find beauty. "Were nature not beautiful," wrote the mathematician, Henri Poincare, "she would not be worth knowing, life would not be worth living. I do not mean here, of course, that beauty which impresses the senses, the beauty of qualities and appearances; not that I despise it—far from it; but that has nought to do with science; I mean that subtler beauty of the harmonious order of the parts which pure intellect appreciates." There are some indeed who moan that the joy and beauty of life have departed and that poetry has been buried under the facts of science. "The gods are dead," moaned W. E. Henley, the English poet,

"The world, a world of prose,
Full-crammed with facts, in science swathed and sheeted,
Nods in a stertorous after-dinner doze!
Plangent and sad, in every wind that blows
Who well may hear the sorry words repeated:
"The gods are dead."

To this we must reply: the phenomena of nature do not lose in beauty as we gain an understanding of them; they become not less but more wonderful, the more fully we learn their meaning. Science does not destroy the beauty of nature, it interprets it; and the gods of joy, of beauty, of wonder and of poetry come back to life as we gaze on the mystery and beauty of the universe which science unfolds to our eyes, and as we see, in imagination, the possibilities of a fuller and nobler life through the widely and more widely opening doors of truth and knowledge.

The Man of Science in the Community

Some there are who, impressed by the mighty achievements of science in the past and confident that still greater boons would be showered on mankind by the greater diffusion of scientific knowledge throughout the body politic, become impatient when they see, as Dr. A. D. Little has recently put it, "in the ranks of science knowledge without power and in politics power without knowledge;" and they demand for men of science a special position of power in the government of the country. Is this demand really justified? Is the claim made on behalf of the man of science not somewhat too arrogant? In connection with some of the practical activities of a government, in the planning and execution of schemes of a technical character, schemes for the conservation and economic utilization of natural resources, in the practical work of national defense, in the control of the purity of food, etc., the claims of the man of science

are indisputable and have been largely recognized. But can we claim for men of science a special place in the general work of government, in the multifarious tasks of adjusting the conflicting claims, prejudices, aspirations of men not only among their own people but as between the different races of mankind? The man of science may, in Dr. Little's words, have "moved the earth from the center of the universe to its proper place within the Cosmos;" may have "extended the horizon of the mind until its sweep includes the 30,000 suns within the wisp of smoke in the constellation Hercules and the electrons in their orbits within the atom," but as a legislator these achievements will avail him little. It is not the 30,000 suns in the constellation Hercules but the 100,000,000 people of his own country that will claim his attention. It is not the motions of the electrons that he should understand but the motives which influence human conduct; he should have expert knowledge not of atomic nature but of human nature, and human nature is not amenable to the laws of science. The more eminent a man is in the domain of creative science, the less successful is he likely to be in the field of politics; and to remove him from his laboratory to the legislative chamber would be to waste his special gifts and ability. One may expect to find agreement among men of science regarding the laws of science, but there is no reason to expect any unanimity among them in the domain of civil legislation. We do not strengthen but rather weaken the cause of science by making claims which neither experience nor reason can substantiate.

But while we ought not to claim for the man of science, as such, a special place in the machinery of government, we shall do well to encourage him to take a fuller share, perhaps, than he has hitherto done in the common duties of citizenship; to place more fully and unreservedly, at the disposal of his fellowmen, that contribution of special knowledge and outlook which his training and studies enable him to make; to endeavor, without ostentation or arrogance, through social intercourse with men of different interests from his own, to form a more enlightened public opinion, and thereby to help in the solution of the educational, social, economic, and other problems which face the community and country to which more especially he owes allegiance.

Value of Scientific Knowledge

To cure or even to ameliorate the evils which flow from the weaknesses to which all democratic government is subject, we must rather work for a greater knowledge and honesty of purpose, a higher cultural level, in the community as a whole; and although we must certainly beware of claiming that the diffusion of scientific knowledge and of the spirit of science is alone sufficient, we may safely claim that it would be an important factor in the moral and social development of the people. "The cultivation of science

in its highest expression," to quote the words of Pasteur, "the cultivation of science in its highest expression is perhaps even more necessary to the moral condition than to the material prosperity of a nation." It is because science inculcates "veracity of thought and action" without which, as Huxley said, "there can be no alleviation to the suffering of mankind," that we must work for its more widespread diffusion throughout all classes of the community. It is, moreover, largely because of its moral and spiritual value, as I have said, that we must claim the inclusion of science in our general educational curricula, whether of the schools or of the universities. A knowledge of the facts of science and of the physical universe in which we live is good and necessary, but if we fail to communicate to the student the spirit of science, the passion for truth, the spirit of coöperation, of tolerance, of charity, and of unselfishness which are the spirit of true scientific endeavor, we shall have failed in our most important work.

In conclusion let me say that while we must urge the claims of science on the grounds both of its practical and spiritual value, we should do so with restraint and moderation, for, in pursuing truth according to the methods of scientific investigation, we must bear in mind that the truth to which we attain is only a partial truth. Let us always remind ourselves of the all-roundness of truth and let us remember that in our scientific approach we see but one side, one aspect of truth. Let us always recognize that through religion, art, literature, and philosophy we have other paths of approach and see other aspects of the truth. Let us then carry with us the thought of the English poet, Sir William Watson, as expressed in his epigram, The Guests of Heaven:

Science and Art, compeers in glory,
Boast each a haunt divine,
"My place is in God's laboratory,"
"And in His garden mine."

Ultra-Violet Light Affects Insulin. That exposure to the ultra-violet rays first increases and then destroys the potency of insulin, is the report of Drs. M. M. Ellis and E. B. Newton, of the University of Missouri, to appear in a forthcoming issue of the *American Journal of Physiology*.

An accepted grade of commercial insulin was exposed to the action of ultra-violet rays from a powerful mercury vapor lamp for periods of time up to 48 hours. The insulin was exposed in an atmosphere of nitrogen in order to eliminate free oxygen and ozone, for it has been shown that insulin is destroyed by oxidation.

It was found that exposures for more than four hours destroyed the power of insulin to reduce the sugar content of the blood and the longer exposures even produced an opposite reaction, increasing the sugar content.

On the other hand, exposures of less than four hours seemed to increase the potency of the insulin, adding to its power to reduce the concentration of blood sugar.—*Science Service*

RAYON—MAN-MADE SILK*

M. G. LUFT, TECHNICAL DIRECTOR, THE INDUSTRIAL FIBRE COMPANY, INC., CLEVELAND, OHIO

Processes of Manufacturing Rayon
Nitrocellulose Process
Cuprammonium Process
Acetate Process
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The International Exhibition held in Paris in 1889 brought a great surprise to the textile world by the introduction of a new synthetic fiber, called by the inventor, artificial silk. No one thought at the time that this new textile fiber, created by close coöperation of chemical and textile knowledge, would be the foundation of one of the most important industrial developments of the twentieth century. Within one generation the new product took its place in the industry as an independent textile fiber with applications in all lines of the textile trade. It represents today the art and refinement in textiles and is influencing our life, giving an attractive and beautiful frame to the picture of modern culture. Still further, it satisfies through its harmony of colors our present artistic desire for color, light, and luster.

The advance in art education and artistic taste called for radical changes in the development of textiles. By the study of art in schools and encouraged by many publications, art museums, and organizations like "The Arts and Industries Foundation," the educated part of the population, especially the women, having the greater artistic taste, created a demand in recent years for more lively and artistic combinations of colors and designs of texture. The post-war period further stimulated the desire for light and color, and, supported by the high average buying power which helps any industrial development, it resulted in a renaissance of the textile industry. Simultaneously, the knowledge of chemistry and its rapidly growing applications to industry found one of its many present-day realizations in the manufacture of artificial silk, known under the generic name of "rayon."

The invention of artificial silk was based on the observation of silk spinning in nature. Scientists observed how the silkworm feeding on mulberry leaves produces the silk fiber and they tried to reproduce this process in a chemical and mechanical way, using as raw material the principal component of the plant structure, which is cellulose, and spinning the solutions of its chemical compounds. The silkworm, changing from the caterpillar to the chrysalis stage in spinning its cocoon, ejects through two extremely fine openings located in its mouth a semi-liquid, viscous substance which hardens immediately upon contact with the air. This is composed of two albuminous substances containing about 80 per cent

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fibroine and 20 per cent serecin, the latter being a soluble gum. In this way one cocoon produces an average of five hundred yards of very fine filament known as raw silk. Such a fiber is never uniform because it is not spun under uniform pressure when the worm moves around, as there is no mechanical exactness of movement or delivery of viscous mass from the glands.

Réaumur, the well-known French scientist, suggested in his book, "Histoire des Insectes" (1734–1742), the imitation of natural silk by human artifice. In Italy, especially on one of the small Venetian islands, Murano, where the glass industry developed several centuries ago, melted glass was pulled with a pointed steel rod whereby the finest filaments of glass were drawn and reeled as a continuous thread. Dresses made of such glass silk appeared as an interesting novelty at the Grand Opera in Paris. Then the chemists turned their attention to the transformation of chemical compounds into artificial fibers, and in 1855 the Swiss, Andemars, patented a process of spinning an ether-alcohol solution of nitrocellulose, a chemical product made by the action of nitric acid upon cellulose. In 1882, Swan, Wyne, Swinburne, and Powell produced in England nitrocellulose threads for carbon filaments for use in incandescent lamps, but their process was not commercially successful. The realization of the idea actually started in 1884 when the French nobleman, Hilaire de Chardonnet, conceived the idea of forcing a solution of nitrocellulose in alcohol and ether, called collodion, through fine capillary openings. In the same year he patented a manufacturing process for artificial silk. He dreamed of replacing the expensive natural silk by such an artificial fiber and for this reason named it artificial silk, not suspecting that this crude substitute would within forty years revolutionize the entire textile industry.

The raw material used for the experiment was identical with the food eaten by the silkworm, namely, cellulose extracted from the mulberry leaves; but while the cocoon fiber is an organic product containing nitrogen and is a typical animal product, the artificial fiber was free of nitrogen and in chemical composition was identical with cellulose. Artificial silk is a synthetic product of vegetable origin because its basis is cellulose and therefore from a chemical standpoint, it is comparable with cotton, flax, and hemp, while natural silk and wool are representatives of products of animal origin.

Artificial silk is not made by spinning or twisting wood or plant fibers together as cotton or wool yarns are made. It is the product of a series of chemical reactions which use cellulose, a vegetable fiber, as raw material. Cellulose consists of carbon, hydrogen, and oxygen which are very abundant chemical elements in nature. Our ancestors used this cellulose in the form of leaves to dress themselves. Then cellulose in the form of cotton became the most important textile product. Now modern chemistry

is changing the leaves into artificial silk to dress and please the present and future generations, and as always it is the woman who gives the inspiration and governs the vogue.

The principle of the manufacture of artificial silk is the transformation of the solution of cellulose compounds into fine, endless, solidified filaments by means of chemical reactions and mechanical appliances. This transformation is made on spinning machines of complicated nature which are of great importance in the manufacture of this commodity.

Early in the nineteenth century the paper machine was invented. At the end of the same century the development of the spinning machine for artificial silk helped to establish this young industrial development. From the raw material to the spinning machine the manufacture of artificial silk is a continuous chemical process which is carried out uninterruptedly day and night. The transformation of cellulose to artificial fibers covers a period of about fifteen days.

The year 1891 witnessed the beginning of the manufacture of artificial silk on a commercial scale in Besançon, France, by the Société Anonyme pour la Fabrication de la Soie de Chardonnet. In 1890 a French chemist, Despaissis, dissolved cotton cellulose in an ammoniacal solution of copper oxide, but it was not until 1897 that Pauly in Germany was able to make use of this discovery for the production of another kind of artificial fiber called cuprammonium silk. In 1892 the English chemists, Cross, Bevan, and Beadle, discovered still another compound of cellulose called cellulose xanthate, formed by the action of carbon bisulfide on mercerized cellulose, which they named "viscose" on account of its high viscosity. This discovery gave the start to the viscose process of artificial silk manufacture, the method used today more widely than any other. About 80 per cent of the total world production of rayon at present is made from viscose and this growing industry is well established in the United States and Europe. About the same time Cross and Bevan produced another compound of cellulose by treating it with acetic acid and this discovery became the basis of the fourth kind of rayon, known as acetate silk.

It took about thirty years before the new textile fiber was perfected in a chemical and mechanical way to the present standard, resulting in a uniform thread of a perfectly equal diameter and strength and more uniform in all respects than the fiber products of nature. After the war, about 1920, the interest of users and investors in this new commodity began to increase rapidly, resulting in the production of rayon which today is produced in greater quantity than natural silk.

Processes of Manufacturing Rayon

The four different processes are still used today, and have in common, cellulose derived from wood or cotton as the raw material, and are all

manufactured by similar chemical and textile operations. The cotton cellulose used is in the form of linters obtained from the short cotton fibers adhering to the seed, and the wood pulp best adapted for the manufacture of artificial silk is that obtained from spruce by the sulfite process. The following table shows the preparation of cellulose.

PREPARATION OF RAW MATERIAL

COTTON LINTERS	SPRUCE WOOD
Cleaning Seed	Barking, Cleaning, and Chipping
Crushing and Pressing	Sulfite (Sulfur-lime, Calcium Bisulfite)
Raw Linters	Cooking in Digestors
Digesting with Caustic Soda	Washing and Screening
Washing	Bleaching (Lime—Chlorine)
Bleaching (Lime—Chlorine)	Washing
Washing	Paper Machines
Drying	Drying
Bleached Cotton Linters (Pressed and Cut in Sheets)	Cellulose (Cut in Sheets)

The chemically purified cellulose is used in the manufacture of the four different kinds of rayon according to the charts shown below.

PROCESSES OF MANUFACTURE

I	II
NITROCELLULOSE	CUPRAMMONIUM SILK
(Chardonnet Silk)	(Also called Glanzstoff or Pauly)
Purified Cotton	Purified Cotton or Wood Pulp Dissolved in Ammoniacal Copper Solution
Sulfuric and Nitric Acids	Spinning Solution
Nitrocellulose Dissolved in Alcohol and Ether	Coagulated by Caustic Soda or Sulfuric Acid
Filaments Coagulated Nitrocellulose Filaments	Filaments of Cellulose
Recovery of Solvents	Bleaching
Removal of Nitro Groups	Commercial Thread
Unbleached Thread Bleaching	
Commercial Thread	

III

ACETATE SILK

Cotton or Wood Pulp Purified

↓

Acetic Anhydride, Acetic Acid, and Sulfuric Acid

↓

Dissolved in Acetone

↓

Spinning Solution

↓

Cellulose Acetate Filaments

↓

Commercial Thread

IV

VISCOSE SILK

Bleached Spruce Pulp
or
Cotton Linters
Caustic Soda

↓

Soda-Cellulose
Carbon Bisulfide

↓

Soda-Cellulose-Xanthate
Water

↓

Viscose Solution
Spinning Solution

↓

Crude Viscose Filaments

↓

Removal of Sulfur
Bleaching

↓

Commercial Thread

Nitrocellulose Process

In the nitrocellulose process, the bleached cotton is nitrated in an operation similar to the manufacture of smokeless gunpowder. Cotton linters are immersed for a period of time at a constant temperature in a mixture of nitric and sulfuric acids in a centrifuge. Then the excess of acids is removed, regenerated, and used again. The nitrocellulose so obtained is washed with water until all acid is removed. The nitration of cellulose is an operation which requires very careful control in regard to the chemical composition and temperature of reaction.

The nitrated cotton, consisting mostly of trinitrocellulose, is dried slightly and mixed with ether and alcohol in slowly rotating tanks until a solution of sirupy consistency called collodion is obtained. Then the solution is passed under pressure to a set of filter presses to remove the insoluble impurities and particles which have not been completely nitrated. The collodion solution is forced by pressure to so-called spinning machines where the liquid is pressed through capillary glass tubes, and the ejected semi-liquid streams emerging from the orifices are collected in groups under tension on rotating cylinders or spools placed in the upper part of the spinning machine. During the formation of filaments, hot air is blown under the covers of the machines in order to evaporate the solvents used in making the collodion. As the solvents are removed the nitrocellulose, now in the form of filaments, solidifies.

The thread wound on the spools consists of several fine filaments which are then twisted on fast rotating vertical spindles on twisting machines, whereby the twisted yarn is wound on horizontal take-up bobbins. The raw yarn is then removed from the bobbins by reeling into the commercial form of skeins on reeling machines.

The yarn, consisting of nitrocellulose, is inflammable like guncotton, and a further chemical treatment is necessary to remove its explosive character by a process of denitration whereby the nitro groups are removed and the thread is left as pure cellulose. This denitration is effected by treatment of the skeins with a warm solution of sodium hydrosulfide. Then the chemicals are removed by washing, the uniform white color of the yarn is obtained by bleaching, and after drying and examining, the skeins which are several thousand yards in length, are ready to be shipped.

This process is quite expensive on account of the high cost of the chemicals used. The solvents, alcohol and ether, are partly recovered and used again for dissolving nitrocellulose.

Cuprammonium Process

A solution of cellulose in ammoniacal copper oxide is the basis of the second process established in this industry. Bleached cotton linters or wood pulp are mixed with fine copper hydrate, and the mixture is dissolved in concentrated ammonia. The resulting blue solution should always have uniform viscosity, also the same copper and cellulose content. The usual solutions contain 3 per cent copper, 7 to 8 per cent ammonia, and 7 to 8 per cent cellulose.

The next step is the filtration of the viscous solution to eliminate undissolved foreign matters, as the liquid in forming filaments is forced during the spinning process through minute orifices and any solid particles contained in the liquid would obstruct the passage and cause the delicate fibers to break. For the same reason air bubbles are removed by vacuum. The purified solution now arrives at the spinning machines and is forced through fine holes called spinnerettes into a setting bath of sulfuric acid or caustic soda. Some manufacturers are applying both chemicals—first caustic soda, and later, for the purpose of final setting, dilute sulfuric acid. Thereby fine filaments are produced similar to the nitrocellulose process.

After the spinning, traces of chemicals must be entirely removed from the fibers by washing with water, because they would affect the quality of the fiber during the subsequent drying. The next and last operation is the bleaching, which results in a purified white product that is very soft to the touch and possesses high luster. The yarn can be dyed in colors by the application of direct dyestuffs, the same as those used for cotton. An important factor in this method is the recovery of the copper and ammonia in a separate chemical plant.

One of the methods used today is based on the experiment of Thiele in Germany. It is the "stretch spinning process" which resulted in the production of very fine filaments of a size as fine or finer than the cocoon fiber. This improved cuprammonium process was used on a larger scale

before the viscose process was developed. In recent years most of the plants in Europe which previously used this system, have changed over to the viscose method.

Acetate Process

Cellulose has the formula $C_6H_{10}O_5$, and contains three hydroxyl (OH) groups. By the treatment of cellulose with acetic acid, two or three acetyl groups are introduced into the hydroxyl groups, acetyl being a part of acetic acid, and the resulting derivative is called cellulose acetate or acetic ester of cellulose. This product is soluble, only in organic solvents such as acetone or chloroform, like nitrocellulose, which is soluble in alcohol-ether, but unlike the cuprammonium product.

In 1894 C. F. Cross patented the first manufacturing process for cellulose acetate. His process consisted of treating purified cotton with zinc acetate and acetyl chloride, two compounds well known in the chemical practice. In this country in 1905, Miles obtained a high-grade product by subjecting the cellulose acetate during its preparation to a special process of ripening. This method permitted the manufacturing of acetate silk and non-inflammable photographic films on a commercial scale. The research work of the brothers Dreyfus in England and in this country during and since the war, resulted in the development of the acetate silk industry.

Bleached cotton linters are treated in large jacketed and enameled vats with acetic anhydride in the presence of glacial acetic acid and sulfuric acid until the mixture goes into solution. This process requires careful supervision and several chemical control tests. The resulting cellulose acetate, which is a mixture of several acetate compounds, is precipitated with water in form of white flocks, washed until it is free from acid, dried, and dissolved in acetone. The resulting clear viscous solution is filtered carefully and delivered under pressure to spinning machines where the spinning process is performed as previously described. The vapors of the solvents are removed, condensed, and used over again in the preparation of solution.

The resulting filaments spun in groups are twisted in the usual way and placed on the market as cellulose acetate, unlike the products of the other systems in which the commercial fibers consist of pure cellulose. Acetate silk is sold in this country under the trade names of "Celanese" and "Lustron."

The expensive chemicals like acetic acid and acetone are partially recovered during the process, but nevertheless this method is expensive and has not yet found a large application in the industry. The resulting yarn does not absorb moisture as readily as the other kinds of artificial silk, and therefore it has less affinity for dyes. This property has so far prohibited its use on a large scale in the textile industry.

Viscose Process

Of all the known methods of artificial silk manufacture, the viscose process has found the greatest application and is used on a large scale in this country. As said before, about 80 per cent of the total present world production of rayon is made according to this method. As raw material, bleached spruce pulp, cotton linters, or a mixture of the two is used. The silk from pulp has a mild, not opalescent luster and dyes more uniformly than that derived from cotton. The pulp, cut in rectangular sheets, is soaked in an 18 per cent caustic soda solution, this treatment causing the fibers to swell and form a compound known as soda-cellulose. The excess of caustic soda is removed in hydraulic presses and after reclaiming is used over again.

Thereafter the sheets of soda-cellulose are shredded to fine crumbs and conveyed to small containers where the soda-cellulose remains at a constant temperature for a period of time undergoing an aging process. The uniform and properly aged soda-cellulose is now transferred to a double-jacketed, air-tight, rotating container where it is treated with carbon bisulfide. This treatment results in the formation of yellow-orange crumbs, a product called cellulose xanthate. The reaction is very delicate and must be controlled carefully to obtain a uniform final product. The purpose of this chemical reaction is to transform the insoluble cellulose into a water-soluble compound, and the resulting solution after preparation in well-insulated, double-jacketed mixers at a low and uniform temperature is called "viscose." The orange-colored, viscous liquid is pumped to the ripening department, where it remains again at a low, uniform temperature for a period of time before it is transferred under pressure to the spinning machines. It is also filtered carefully and freed of air bubbles by vacuum before it is converted into filaments.

The viscose is now pumped through mechanical regulators which are placed on the spinning machines, each regulator pumping a constant amount of viscose to the outlets fitted with platinum nozzles. The solution forced through the minute holes of the nozzles is divided into very fine streams which, passing through the precipitating bath of sulfuric acid and other chemicals, are immediately coagulated and the streams of viscose solution are converted into fine filaments of regenerated cellulose. The size of the spun thread is determined by the amount of solution of known cellulose content projected through the nozzle in unit time and by the rate of speed at which the thread is collected. As in the previously described methods, the collected filaments are converted into skeins of twisted yarn.

The viscose process requires the continuous attention of the chemist during several complicated stages, for unstable compounds are being formed. The working formulae must be established entirely independent of

climatic conditions, and the slightest irregularities in the chemical process must be avoided, as they would influence the product and might mean the difference between success and failure.

During the spinning of viscose, different by-products are formed containing sulfur derived from the carbon bisulfide used. These impurities are removed from the skeins by treatment with sodium sulfide solution and bleaching with chlorine. These operations are also very delicate because they may cause destruction of the yarn. After bleaching, antichlor is applied to remove the traces of chlorine and the skeins are then washed until all chemicals are eliminated, the excess water is removed by a centrifuge, and the skeins are dried. From the drier the skeins enter the inspection department where each skein is examined and graded for quality, great care being taken to see that the silk absorbs a uniform amount of moisture from the atmosphere. Finally the skeins are wrapped and bundled under pressure in ten-pound packages ready for shipment.

The size of rayon yarn is defined by the metric denier standard, the same as employed in measuring the size of raw silk. The finer the silk, the smaller is the denier. Two standard sizes, namely 150 and 300 denier, are the most frequently used in the textile industry. Ten thousand yards of yarn weighing 150 grams are 150 denier; similarly, ten thousand yards of yarn weighing 300 grams are 300 denier. Accordingly, one pound of 150 denier contains 30,000 yards and one pound of 300 denier 15,000 yards. The corresponding sizes of cotton are Nos. 30 and 15, respectively, No. 1 cotton yarn having 840 yards to a pound.

Properties of Rayon

One ton of purified sulfite pulp produces in the manufacturing way about 1500 pounds of silk, equal to forty-five million yards of standard yarn. One spinner produces every day in eight hours three million yards of the same standard. The price of wood pulp is about five cents a pound and that of a good grade of rayon, two dollars a pound. This difference in price is a good illustration of the value and earning power of research, which, based on the ingenuity of chemists in applying intricate methods, is able to increase many times the value of the raw material. It also shows in dollars and cents the financial power and value of chemistry in industrial applications, the chemist's work in this industry being a transformation of one kind of cellulose into another. Of great technical importance in the rayon industry is the mechanical equipment, the organization of production, and the continuous chemical control of complicated processes. The coördination between the mechanical and chemical operations requires the highest precision in each stage of the continuous process, whereby the consecutive stages must be synchronized and correlated under detailed attentive control of management.

Rayon manufacture is today a well-established industry, based on skilled labor and technical ingenuity combined with common and most abundant raw materials and chemicals obtainable all over the industrial world.

Artificial silk is a soft, pliable, multi-filament textile fiber which owes its large application in all textile commodities to its uniformity, fine luster, and high dyeing quality. Like all other kinds of textile fibers, rayon must resist wear and tear, and the desire of our present industry is still further to increase the strength of artificial silk. Fabrics made of rayon or of mixed fibers containing rayon must be handled carefully, like any kind of delicate fabric. Rayon partly loses its strength while wet, but regains its previous strength after drying. If handled carefully, rayon resists all the usual treatments with chemicals, also higher temperatures; for instance, boiling water can be applied without detrimental results. Generally, rayon garments should be a great advantage, and artificial silk combined with cotton or real silk is used more and more as an ideal yarn for shirts and underwear. It has still another advantage in this respect, because natural silk rots from perspiration and turns yellow, while artificial silk remains white. Real silk is generally weighted with metallic salts, in some instances, as in black fabrics up to 300 per cent of the original weight of the yarn, and this content of foreign matters makes silk brittle and is not conducive to good health. Artificial silk, however, is never weighted; it is a pure cellulose product and, therefore, has no injurious effect on the skin. The gloss and brilliancy of artificial silk surpass that of natural silk and all other fibers, because the individual filaments are flatter and present a greater light-reflecting surface than the cylindrical natural silk fibers which reflect a relatively smaller amount of light.

The different kinds of rayon have not the same luster, nitro silk being shiny, copper silk glassy, and viscose silvery, more like natural silk. Also the feel of viscose silk is similar to natural, but slightly colder and harsher to the touch. Any degree of softness of rayon can be produced during the manufacture, the softness being the result of the number of single filaments drawn from the cellulose solution. The rayon filaments can be spun as fine as cocoon fibers.

Artificial silk may be identified by its chemical and physical properties, the simplest test being the combustion test. It burns like cotton with an odorless flame and leaves no residue but a small amount of ash, while natural silk and other animal fibers smoke without burning, giving off a disagreeable odor like burnt horn, and leave a charred residue. Natural silk and wool dissolve in a concentrated solution of caustic soda, washed by hand at a temperature of 150°F., with a good grade of neutral soap.

When the rayon industry began to develop and only nitrocellulose silk was in use, a general opinion was formed that the product was inflammable.

This prejudice has disappeared and today rayon is regarded as no more inflammable than cotton or other kinds of textile fibers.

The work of a productive chemist is not only to make the invention but to manufacture the product and to adapt its qualities to any kind of application. The weaving industry requires a fiber which has a high covering power, imparting full body to the fabric. This property has been greatly improved in the manufacture of rayon thread by the application of special chemical reactions during the precipitation of the fiber, whereby round or flat filaments are produced by altering the composition of the setting bath. Also, waterproofing of artificial silk has been greatly improved. When treated with water the fiber absorbs a large amount of liquid, increasing in volume by 40 per cent, but when dried it contracts and regains its former volume. This ability to gain and lose water is due to the capillary structure of the fiber and the large surface of the filaments. Its physical structure can be changed by chemical reactions and there are many processes known for the waterproofing of artificial silk, one called Sthenose being based on the treatment of the yarn with formaldehyde and lactic acid.

On the other hand, the power of absorption of moisture is an advantage of rayon when used for underwear, because it absorbs the perspiration from the body and permits the evaporation of the excess moisture, thus keeping the skin dry and comfortable. This hygienic property has but recently been recognized.

Applications of Rayon

In all branches of the textile industry, rayon is used independently of other textile fibers or in a supplementary way. With cotton it is used to a large extent for underwear, hosiery, ribbons, all kinds of pile fabrics, shoe coverings, cloths, umbrellas, and for wire insulation. It finds a growing application for bedspreads, draperies, trimmings, elastic webbing, satin, laces, embroidery, and being more resistant to friction than natural silk, it is valuable for hat and coat linings. It is replacing cotton in many fields, because the supply of long staple cotton has been greatly reduced and its price is gradually approached by artificial silk which in addition has the advantage of being produced in endless lengths.

Growers of cotton will not be forced out of business by the growth of the artificial silk industry, but it may reduce the production of cotton and stabilize prices and establish reasonable profits for the cotton industry. Part of the cotton production, namely the short linters, will find its place in the rayon industry as raw material. Many authorities claim that cotton in the future will be replaced entirely by artificial silk. However, this expectation has no foundation, considering the present stage of development of this young industry. Should this ever take place, it will

not be in a revolutionary way but by means of slow adaptation and chemical evolution during the generations to come. It is more probable that the agricultural conditions of the country will be adjusted. The supply of wood for pulp in this country may be exhausted unless a radical reforestation policy is established. It would also be beneficial to cotton growing if the reforestation of the cotton belt were encouraged, thus better protecting the parts of land used for cotton. Another solution of the competition between cotton and rayon would be to find better methods of mercerization to increase the value of cotton, and this would again be the function of the chemist. To the great task of the chemist within this industry may be added his worries about cotton and rayon, which are like those intimated in the sign on a livery stable, "Horses clipped and rubber tires put on."

In combination with natural silk, rayon is used largely for hosiery, ribbons, silk fabrics, and brocades. It is used for crepes, mousselines, fur imitations, plush, and velvet. It has further use for the skeletons of gas mantles, toys, artificial hair, and for millinery purposes either alone or in combination with metallic cloth. Artificial silk waste is corded, combed, and spun with wool or used alone for fringes, tassels, button coverings, and felt. Artificial horsehair and artificial straw, known on the market as "Visca" and used for millinery purposes, are also made from viscose. The product is obtained during the spinning process by pressing the solution through nozzles of a different size and shape than those used for rayon. Rayon is also used in connection with rubberized cloth for surgical dressings, and being a poor conductor of electricity, it is used for insulating purposes on electric wires and magnetos.

A generation ago when in England the first attempt was made to manufacture artificial silk, people having a prejudice against the new result of chemical development laughed, claiming that "they try to make silk stockings out of cabbage." Today, this prejudice has been overcome and there is not one branch of the textile industry which would hesitate to use rayon or deny the good results obtained.

Dyeing of Rayon

One of the most striking advantages of rayon, especially of the viscose product, is the dyeing quality. It takes the substantive and basic colors, the latter with or without mordant, very uniformly, resulting in brilliant colors of the yarn. If fabrics made of wool or natural silk mixed with rayon are dipped in a dye-bath containing two different dyes, two or three color effects are obtained simultaneously, a process known as cross dyeing which is applied to brocades and other fabrics. Similar are the results of alternate weaving together of viscose and acetate silk which have a different affinity for the same color in the dye-bath. In the printing of mixed or

rayon fabrics, it is possible to produce very elaborate color designs with striking effects at a much lower cost than would be the case if the fabrics were produced by weaving the different colors on Jacquard machines. On the printing machines as many as eighteen different colors can be produced simultaneously on one fabric. This produces a rich material, striking in depth of color and beauty of design, and such fabrics are used for expensive gowns and neckties. The gift of an artistically woven and dyed, or printed dress made of rayon is appreciated by many wives and daughters, although they may still prefer jewels instead.

World and Domestic Production

According to the records of the Textile Division of the Department of Commerce at Washington, D. C., the domestic production of artificial silk increased from one and one-half million pounds in 1913 to thirty-nine million in 1924, the latter output representing a value of about eighty million dollars. The world production in 1913 was about twenty million pounds and in 1924 the one hundred million mark was passed, of which almost 40 per cent was produced in the United States. The production and consumption of rayon are today far in excess of that of natural silk and, according to some authorities, are nearly double. The domestic production is growing rapidly and about one hundred million dollars of capital are invested in this industry. The superior quality of rayon made in this country and the efficiency of the manufacturing methods enable us to compete with countries where labor is cheaper and make us independent of imports. In 1923 seven million dollars' worth of rayon was imported by this country from Europe and in the following year the imports dropped to two million dollars. The imports supply our domestic market with lower and cheaper grades than those produced here and this reason, added to the rapid growth in the production of artificial silk in this country, explains the gradual diminishing of imports from foreign countries.

The United States is today the largest producer as well as consumer of artificial silk, because the industry is built on large-scale production and the success of the operations depends upon large financial reserves. The process is intricate and requires the handling of large amounts of material for a long, continuous period of time on complicated and expensive machinery.

Opportunities for Chemical Research

Is artificial silk an ideal fiber? There are several problems to be solved before this question can be answered favorably. The present process of manufacture requires a long run and the study of the technical chemist may result in a shorter process. He must study the different reactions of aging, with a view toward shortening the time. Uniformity of the aging process must be established and controlled by means of simple testing

methods. The by-products resulting from the reactions applied in the manufacture have also commercial value, and the study of methods for their complete recovery is another important field for chemical research. Other by-products like hydrogen sulfide, generated during the transformation of viscose solution to cellulose thread, must be eliminated as they affect unfavorably the manufacturing process and involve complicated systems of ventilation. The chemical and physical control of testing methods of this young industry is not yet standardized. The knowledge of organic chemistry and analytical ability are necessary to study and perform the complicated research supported by continuous observations of all the reactions involved. Also a knowledge of textile operations is necessary because the consumer having difficulties in the handling of artificial silk will always refer complaints about the yarn to the manufacturer. The chemist must have artistic taste to judge the color, touch, and luster of the yarn itself and the fabrics made from it.

Rayon loses part of its strength when in a wet state and the problem of its water resistance gives the greatest opportunity to the chemist. Rayon produced in such quality that its strength while wet will be almost or entirely equal to the strength of the dry product would be a dominant factor in the entire textile industry. What becomes of the waste of rayon dresses? Consisting of pure cellulose, this could be utilized as an ideal raw material in this growing industry.

The preservation of natural resources is also the task of the chemist who may be able to synthesize the wood, the raw material for rayon. The structure of cellulose is not yet defined, therefore analytical methods for testing raw material are not perfected. The chemical behavior of cellulose in the processes depends on the climatic conditions under which the plant cellulose grows, the result being that the cellulose in physical structure and chemical composition is not homogeneous and is often beyond technical control during the manufacture of artificial silk. The textile industry based for centuries on mechanical traditions at first mistrusted the chemist. Today, evolution of the textile industry through the introduction of the synthetic fiber is on the way to be accomplished satisfactorily, resulting in refinement of blended fabrics and harmonious, lively colors.

Chemical research on such problems is the foundation of the industry. It is comparable with the financial budgeting of any commercial organization. Chemistry as a science is the organized knowledge of matter and energy, and if applied in a productive way to the industry, it spells success.

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Wearability of Steel Tested Electrically. How different kinds of steel will wear under all sorts of conditions can be tested accurately in the chemical laboratory. Dr. H. Beeny, a metallurgist from Sheffield, England, who addressed the recent meeting of the American Electrochemical Society, told how he used the method to test the effect of manganese in the corrosion of steel.

A piece of steel and a piece of gold, connected by copper wire, were immersed in a weak salt solution, and the corrosion taking place on the steel set up an electric current which was measured. Dr. Beeny claims that corrosion in the air as well as corrosion in a solution is never "purely chemical," but electrochemical.

Mercurochrome Helpful in Leprosy Treatment. The recently developed antiseptic mercurochrome has been found beneficial in the treatment of lepers at the U. S. hospital at Carville, Louisiana, according to a statement made by a group of physicians in the U. S. Public Health Service. While the chemical has not given indications of being a specific cure, its use has, in many cases, been followed by definite improvement of certain stubborn and distressing symptoms.

The use of this new antiseptic, which is an organic compound of mercury, is reminiscent of earlier efforts in the treatment of leprosy, where calomel and other inorganic mercury salts were used. The new material, however, gives much more encouraging results than the old.—*Science Service*

Chemical Aladdin's Cave Found in Germany. A series of grottoes, mined for alum and vitriol long before Columbus was born and rediscovered shortly before the World War by the Berlin geologist, Dr. Hess von Wichdorff, have just been found to be a veritable chemical treasure trove. A spring claimed to be the "strongest" spring in the world issues from one of the most beautiful parts of the grottoes and contains phosphorus, arsenic, and iron sulfate.

Minerals of the rarest colors jewel the caves in numberless many-hued formations. Chemists, physicists, and geologists, who examined the springs and minerals systematically for a year and a half from a scientific and medicinal viewpoint, have found radioactive springs such as have never before been found. Tests have revealed that the springs are almost bubbling drugstores. Besides phosphorus, iron, and arsenic, they contain in addition molybdenum, copper, aluminium, manganese, calcium, magnesium, sodium, and potash.—*Science Service*

THE JOINT MEETING OF THE DIVISION OF CHEMICAL EDUCATION AND THE SECTION OF HISTORY OF CHEMISTRY AT THE LOS ANGELES MEETING OF THE AMERICAN CHEMICAL SOCIETY, AUGUST 3–8, 1925

The joint session of the Division of Chemical Education and the Section of History of Chemistry was called to order by Chairman W. A. Noyes. The session opened with a symposium on "What Are Our Objectives in Teaching Chemistry?" The discussion was lead by W. C. Morgan, J. E. Bell, L. F. Foster, Alexander Silverman, H. I. Schlesinger, and Wilhelm Segerblom. Dr. Morgan introduced the subject by pointing out two fundamentally different schools of thought as to the methods of training teachers: (*a*) the "normal school method" in which the emphasis is placed on the method of presentation without due regard for the subject-matter; (*b*) the "college professor method" which goes to the other extreme with the idea that if the teacher knows the subject, that is all that is necessary. "One emphasizes the recipe, the other the materials." "A good teacher must first know his subject and then have the elements of the fine art of teaching." In speaking of the content of our beginning courses, Dr. Morgan said that, "of the material in the College Entrance Examination Board questions, 80–90% is informational matter. Of this statistics show that 85% is forgotten within a year. Therefore, why give pupils so much informational material? Take each year's work as a new proposition; carve out the work as an artist does from a block of wood. If the student learns chemistry as he learns to swim, he will not forget 85% in a year. It's the teacher's business to open the student's eyes and to develop the ability that lies inherent in him. Teach the scientific method first and foremost, working on the inductive method, since it will stay with him all his life. Interest lapses when informational matter is given."

Dr. Bell continued the discussion by pointing out that the beginning course is all the formal chemistry the vast majority of students will ever get. Since they will probably be future leaders in society, they should be trained to think, to exercise judgment and to have the courage of their convictions. There are few subjects, if any, he pointed out, better adapted for this purpose than the subject of chemistry. There is probably no better place for the student to begin the scientific method of study than in the subject of chemistry and since this tends to produce open-minded and clear-thinking men and women, it should be the main objective of the chemistry teacher.

Mr. Foster described the method of handling chemistry at the University High School, Oakland, California. He spoke of a need for a revaluation and reorganization of the subject-matter of chemistry in secondary schools made necessary not only by the introduction of general science into

the curriculum but also by the recent discoveries in the field of atomic structure which offers a fundamentally different idea of chemical phenomena and is so important as to require a prominent place. In the University High School the class discussion serves as a center from which the activities of the class radiate. No special text-book is followed and work in the laboratory is carried on through the medium of problems which arise during class discussions. Individual and independent thinking is especially encouraged.

Dr. Silverman emphasized sectioning on the basis of ability wherever possible and suggested that students be allowed to do independent work. The instructor should simply direct the students in self-education. This can be done most effectively, he believes, in the laboratory. Therefore, questioning students in the laboratory is invaluable. Abolish grades and give credit for the quantity of work well done.

Dr. Schlesinger spoke more particularly of freshmen students with high-school preparatory work in chemistry. He emphasized chemistry as a part of a liberal education and gave a number of examples in illustration. Since the student forgets properties of substances, he advised the use of the inductive method. "Combine descriptive material with the essential aim of teaching chemistry—the development of the intellectual power in any walk of life into which the student may go."

H. R. Smith's paper brought out the three following objectives: (1) welfare and interest of pupil, (2) acquisition of the scientific habit of reasoning, and (3) gaining ability to form generalizations.

The final paper of the symposium was presented by Wilhelm Segerblom, who gave as our objectives in teaching chemistry seven fundamental aims, *viz.:* instruct our students, train them, inspire them, give them the discipline of the scientific method, give them power to interpret, aid them by explanation and guidance, give them the ability to find recreation in chemistry. All students need some fundamentals, he continued, but the amount should be reduced so that about a third of the time could be used in a manner to suit the special needs of the class.

At the close of Mr. Segerblom's paper, the subject was opened for general discussion.

Coates, University of Louisiana.—"I am confident we are not giving students what they ought to get. I am getting more dissatisfied with our methods of pedagogy. Many of the critics of the present pedagogy of chemistry don't know what they are talking about. Every teacher of chemistry I know at the present time is doing his very level best for the student in his classes, worrying his head trying new methods of teaching for the purpose of benefitting his students. Suppose the student does forget 85% of what is given him. It is not a fair thing to estimate intellectual progress in percentage. The hard thing with the first year man

is to make him work at all. My problem is how to get a freshman to study. Freshmen are growing up, enlarging in their intellectual abilities, and it is chemistry that has as much to do with this as anything. There are two objectives, first, cultural, second, intellectual training in the use of the scientific method. Inductive reasoning is the hardest kind of intellectual process and very difficult for the high-school student. Information is not a bad thing to have in chemistry. However, I do not give it to my own students."

W. A. Noyes, University of Illinois.—"I think there is a great deal of mistaken notion with regard to induction; it has not been used in the majority of our advancements in science. We must have both the idea and the facts."

At this point there was some discussion regarding the value of standard tests and a motion was made by Dr. Gordon that a committee be appointed to formulate some of these tests for trial. "We may go wrong," he said, "but if we try something, we will get farther than doing nothing." The general opinion, however, was against standardization and the motion was withdrawn.

J. D. Clark, University of New Mexico.—"Chemists have not taken definite account of the real things needed by the students for the courses they are taking. Educators have been very definite in setting forth aims, of which there are three: civic, vocational, and avocational. The student must be trained for worthy home membership, improve his worth, give him something to use in his vocation and make him a worthy citizen. We are laying too much stress on the vocational aim. We need our aims set forth and put on a chart."

J. H. Hildebrand, University of California.—"We should try to teach chemistry as a science. I am very much afraid of any standard curriculum or any objectives on a chart. If you go through any scientific study so intent on the by-products, you lose the value of interest in the subject."

C. W. Gray, Hollywood High School, Los Angeles, California.—"By means of reports of high-school students from their colleges, I find that the objectives are to prepare students for sophomore chemistry and to prepare teachers. The teachers should create interest. Our big trouble now is that teachers come to the high schools unprepared."

Alexander Silverman, University of Pittsburgh.—"Elementary teachers must be more thorough than advanced teachers. The answer lies in the thoroughness and maturity of the teacher and his experience. General science now precedes other sciences. This is too much for even the best trained."

Miss Patton, Medford, Massachusetts.—"How can we enforce and carry out these ideals? Every day I try to give my pupils something that will make their eyes stand out."

At the opening of the second day's session, Chairman Noyes appointed the following committee to nominate officers for the coming year: W. C. Morgan, Alexander Silverman, and H. I. Schlesinger.

J. H. Hildebrand then presented a paper on "Final Examinations in General Chemistry." In addition to showing a number of sets of examination questions that had been given at the University of California, he pointed out that principles should be taught and power developed rather than merely facts imparted. While final examinations give a very considerable revelation of what is being taught, they are not the sole criterion of the value of the course. In large classes where sectioning is necessary, it is very important that students feel they are being treated fairly and squarely and that their ability in chemistry is honestly being reviewed; hence examinations should be of a kind that do not depend upon the whim or judgment of the marker.

In the discussion which followed, it was brought out that weekly tests caused about 15% to drop out before the end of the first semester and an additional 10% to fail; but in the second semester the survival is very good. Much time is saved in marking examinations. Particular emphasis is placed on the periodic system and atomic structure. Students are made to feel they are somewhat near the period of advancement which serves to stimulate and encourage some of the better ones to go on into chemistry.

In a paper on "Correlating Organic with Inorganic Chemistry," Roger Williams pointed out the close relationship between organic and inorganic acid anhydrides, the value of the periodic system in correlation, and the study of carbon. He discussed compounds of the type CH_3Cl and CH_3OH, pointing out their acid character and their electrostatic attraction, *e. g.*, $NH_3 + HCl \longrightarrow NH_4Cl$.

"What Is the Chemistry Teacher Trying to Do?" was the subject of a paper presented by J. E. Bell. The whole idea of chemistry is removed from the student's field. He does not understand the language, hence the teacher must avoid giving too much and going too fast, since it develops an inferiority complex and causes the student to lose interest.

Discussion brought out the idea that fundamentals should be given though it is difficult to agree on what they are. The truth should be taught but in a beginning course such truth as the student can see. When things cannot be tested, they are better left for a later course.

In his discussion of some difficulties confronting chemical education, Neil E. Gordon said that one of the biggest problems is that of keeping the national program of chemical education in harmony with the different states and with the different phases of chemistry. As a solution of this problem he suggested a Senate of Chemical Education, and after some discussion it was moved, seconded, and carried that a Senate be formed which should consist of one high-school, one college, and one industrial

man from each state; a chairman, a secretary, and such other officers as the Senate should approve after it had become fully organized. All Senators are to be members of the A. C. S. and elected by the respective state organizations of Chemical Education. There is to be a session of the Senate at each semi-annual meeting of the A. C. S., and at such other times and places as the business of the Senate demands. The following objectives of the Senate were given:

1. To permit each state and each phase of Chemical Education to have equal representation in all educational projects carried on by the A. C. S.
2. To decide upon what questions should engage the concentrated attention and money of the Division of Chemical Education of the A. C. S.
3. To keep the State organizations in tune with National organizations
4. To bring about closer coöperation between high schools, colleges, and industries and thereby unify the efforts of all those interested in Chemical Education
5. To plan for the future development of Chemical Education in the country.

In explanation of how a closer union may be brought about between universities and industries, Dr. Gordon outlined the plan used at the University of Maryland whereby an industrial job is manned throughout the year by students, with satisfaction to both university and industry.

The third session was devoted entirely to History of Chemistry. Dr. Edgar F. Smith spoke in his usual interesting manner of a number of early chemists whose contributions to the development of chemistry he showed to be very real but who have been overlooked. Among those mentioned were the Dutch chemist, Van Diemann, who decomposed water by means of electricity; Gene LeDuc (1727) who showed that the maximum density of water is reached at 4°C.; Carl Ackhardt (1735) who made the first platinum crucible and used it in his work; John F. Gmelin (1748) who wrote a splendid history of chemistry in three volumes; and Ioann Wallerius, the father of agricultural chemistry.

Professor W. A. Noyes followed with a description of his method of teaching the history of chemistry. He stressed the value of getting away from the idea of a final examination in order to relieve the student of that fear so he may study the history for its own sake. One important feature of the course consists of reports by the students on the lives and works of prominent chemists. The students are expected to talk about the man, not read a paper.

Owing to the inability of Dr. C. A. Browne to be present, his paper on "Historical Notes upon the Domestic Potash Industry in Early Colonial and Later Times" was read by Dr. Gordon. The last of the history papers was the description and exhibition by LeRoy S. Weatherby of one of Joseph Priestley's alchemist manuscripts.

C. W. Gray opened the last session with a paper on "Real Minimum Essentials of High-School Chemistry." He pointed out three aims that

should be considered in such a course, *viz.*, interest in chemistry, familiarity with a certain amount of chemical theory, and training in planning and performing experiments and reasoning about them. Owing to the immaturity of high-school students, there must be less work and more drill. Such a minimum course should not be made to cover more than sixty recitations, the remainder being left for the teacher to use in a manner best suited to his students. In choosing the subject-matter, two essentials in teaching chemistry must be kept in mind, the first, intangible, is to give scientific attitude and truth; the second, tangible, is to teach general principles of chemistry thoroughly. Today there is little theory that need be given the high-school student, he said. Give laws, but put them over through descriptive material.

"A Logical Presentation of General Chemistry" was the subject of a paper read by Dr. O. F. Stafford. This paper was the result of several years' experience at the University of Oregon. It differs quite radically from the usual method in beginning with the simplest form of chemical change and developing the subject through the more difficult chemistry. He advised the use of visible, tangible experiments, particularly in the beginning. He finds no significant loss through postponement of the gas laws till late in the course. "Emphasize points," he said, "so that the student knows and uses the processes by which chemists see and understand chemical relationships."

W. M. Latimer spoke on "The Problem of Quantitative Analysis." Technique, preservation of the idea of the experiment, and the teaching of chemistry were stressed as the three important factors. Students should take an experiment apart, he said, and one test one factor and another, another factor. This involves teaching inorganic, physical, and other branches of chemistry.

The final paper of the session was presented by C. S. Adams, "A Cultural Course in Chemistry." He described the Antioch plan of coöperative education where the student alternates five weeks in school and five weeks at work, requiring six years for graduation. The objects of the course are to develop character, intelligence, and power. Chemistry is considered a cultural, educational course and is required of all students. Much outside reading of such books as Slosson's "Creative Chemistry," "Chemistry in Industry," etc., is required. The plan, he said, prevents misfits, is a means of partial self-support, and prevents mental indigestion.

C. W. Gray showed some very interesting models and charts made by Hollywood High School students. Among these were a gas plant, sulfuric acid plant, Bessemer converter, hydrochloric acid plant, etc.

The committee on nominations reported the following as officers of the Division of Chemical Education for the ensuing year: *President*, Wilhelm Segerblom; *Vice-President*, A. P. Cady; *Secretary*, B. S. Hopkins; *Busi-*

ness Manager, E. M. Billings; *Executive Committee*, J. H. Hildebrand, H. I. Schlesinger, L. M. Mattern. On motion made, seconded, and carried, the secretary cast the ballot for the above officers.

Motion was made and carried that the chairman of the Committee of Chemical Education be ex-officio chairman of the newly organized Senate.

On motion the Division adjourned.

G. W. SEARS, *Secretary pro tem.*

Lead Transmuted into Mercury and Thallium. Further evidence in favor of the transmutation of the elements comes from the experiments of Arthur Smits and A. Karsen of Amsterdam. They followed the general method by which Professor Miethe of Berlin claims to have obtained gold by passing a strong electric current through mercury vapor. The Amsterdam chemists undertook the decomposition of lead instead of mercury. This was more difficult since lead is converted into vapor at much higher temperature, and considerable time was consumed in constructing a practicable ultra-violet ray lamp of quartz with lead in place of quicksilver.

The rays given off were examined with a quartz spectroscope. After a current of thirty to thirty-five amperes under a pressure of eight volts had passed through the apparatus for six hours, certain lines characteristic of mercury began to appear in the spectrum. These gradually strengthened until after ten hours the entire series of mercury lines and also those of the rare element thallium were perceived in the visible and ultra-violet parts of the spectrum.

The lead employed was specially prepared and purified for the purpose by Kahlbaum of Berlin. If the lead was indeed absolutely free from other metals the experiment appears to prove that lead can be broken up into at least two other elements.

The question of possible impurity of the metal at the start is the basis of the criticism of these alleged transmutations. A new and sharp attack on Miethe's experiments comes from the laboratory of the Berlin University Chemical Institute where E. H. Riesenfeld, Wilhelm Haase, Erich Tiede, Arthur Schleede, and Frieda Goldschmidt find that the process of purification employed by Miethe prior to the passage of the electric current did not altogether remove the traces of gold that occur commonly in mercury. By distilling the mercury three times in a vacuum they were able to obtain mercury that gave no indication of gold, even by the most delicate test, and when this was used in an electric lamp according to Miethe's method, no gold was obtained.

But Professor Miethe says: "My newest method yields an amount of gold far greater than my previous method, in fact enough to permit me to determine gold by the standard chemical tests."

This new and more powerful method has not yet been tried on the Riesenfeld gold-free mercury.

Professor Miethe also found, besides the gold, traces of another metal in the mercury and this he takes to be silver. Professor Nagaoki of Tokyo, who reported getting gold from mercury by electrical action, also found a white metal which he thinks is platinum.

If these experiments are confirmed, chemists have acquired the power of changing lead into mercury and thallium, and then the mercury into gold and silver or platinum. This would open a new era in the sciences, the synthesis of the elements.—*Science Service*

A CENTURY OF ALKALOIDS

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General Properties
Isolation
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Opportunities Remaining

One hundred years of usage has given the term "alkaloid" a place in chemical, medical, and pharmaceutical literature, more secure than any arbitrary definition or any detailed description can explain. The term, in fact, early acquired a prestige which it still holds.

So generally has this prestige been recognized that other compounds, intended for medical use, have been described as new alkaloids, thus obtaining such commercial advantage as comes from inclusion in a class of highly valued articles.

There has been, as yet, no acceptance of any suggestion to narrow the definition to pyridin and quinoline derivatives.

But as the constitution of these substances becomes known and especially as synthetic production in commercial quantities is accomplished or is made possible, it is likely that the term "alkaloid," while remaining in use, will not be an all-sufficient descriptive classification for so many substances as it now groups together.

Thus caffeine was defined in the United States Pharmacopoeia of thirty years ago as "a proximate principle of feebly alkaloidal power," twenty years ago it was "a feebly basic substance," and now is "tri-methyl-xanthine."

The first reported use in an English publication of the word "alkaloid" was in Ure's Dictionary of Chemistry in 1831—"They are called by the German chemists, alkaloids."

The classification "alkaloid" is usually limited now to bases first derived from plants or these same articles prepared synthetically, and the salts and derivatives of these bases.

The number of such bases known has increased to something less than two hundred and quite a number of salts and derivatives of each have been prepared or described.

General Properties

In general, all are bitter, often extremely so; nearly all are physiologically active, usually to a noteworthy degree in small doses; many are tertiary amines; all are composed of carbon, nitrogen, hydrogen, and, in most instances, oxygen.

Most of the alkaloidal bases are rather freely soluble in either chloroform, ether, benzene, naphtha, acetone, alcohol or fatty oils, and are sparingly

soluble in water. They unite with acids to form salts. This reaction proceeds as it does with ammonia—without the elimination of water. The salts are usually sparingly soluble in solvents for the bases but, unlike them, also dissolve readily in water, alcohol and water mixtures, dilute acids, and glycerin.

Isolation

These solubilities, today accurately determined for many of the substances, so clearly indicate schemes for the isolation and purification of alkaloids, that we may wonder why this much-sought separation from the parent crudes was not accomplished at an earlier time. Early investigators, those prior to the second quarter of the last century, did not have such large commercial supplies of chloroform, ether, naphtha, benzene, etc., as are now so universally available. These readily volatile solvents in a high degree of purity are necessary materials in the isolation of many highly purified alkaloids as now practiced.

The isolation of nearly all the more important alkaloids was, however, accomplished in the first third of the last century. It was the successful culmination of a fantastic and erratic search of ages past for the active components of plant products valued for their healing properties. The alchemists' work on the transmutation of metals was rivaled by the quest for the "ideal quintessences" of long-used drugs.

Robert Boyle, in England, nearly three hundred years ago, treated opium with a crude potassium carbonate and extracted with spirit of wine obtaining a solution that we now say contained opium alkaloids. Boyle's work was a good beginning on opium. This same procedure has been followed in recent times in Germany as part of the isolation and purification of morphine commercially.

The successful isolation of alkaloids was first accomplished by a group of able Frenchmen, though the French Institute gave ample recognition to the work of Serturner, apothecary of Eimbeck, Hanover, and also to the Scotch and English physicians and chemists whose work contributed to the same end.

Nomenclature

It has now become a very generally accepted practice to use the termination *ine* in the English names of alkaloids and in medicine and pharmacy this termination is being reserved for such names. The English names of glucosides and neutral principles usually have the termination *in*.

Many of the names of alkaloids suggest the names of the parent crudes, as cinchonine from cinchona; other deductions, however, are less certain. A few names refer to the physiological action, as morphine from Morpheus, but these suggestions are not always trustworthy; such physiological activity as is possessed by narcotine is as a tetanic and excitant.

In 1818, when Pelletier and Caventou isolated strychnine, they proposed naming it vauqueline, to honor Vauquelin who was then credited with being the first to establish the existence of an organic alkali. He was a leader in the chemical investigations of the time. His published papers numbered 376 and he made known two elements, beryllium and chromium. Though he prepared an impure form of nicotine in 1809 and of daphnine in 1812, it is doubtful if he isolated any alkaloid in a high degree of purity. Members of the French Institute pointed out to Pelletier that this proposed use of Vauquelin's name was a doubtful honor since the new substance was destructive to human life and had other uninviting qualities. So the name strychnine, referring to the plant from which it was derived, was chosen instead. Sixty years later, Tanret (1878–1880) used the names pelleterine, methyl-pelleterine, iso-pelleterine, and pseudo-pelleterine for four alkaloids separated from pomegranite root bark. Are modern sensibilities less acute? Perhaps it was held that pelleterine being very serviceable as a taenicide was beneficial to man, though destructive to worms.

Commercial Considerations

The searcher for an alkaloid was certain from the beginning of his work that there would be a large demand at a good price for the object of his search. In early investigations the work was based on crudes, already highly valued and used in generous quantities when available.

The revolutionary increase in transportation facilities, bringing forward quantities of crudes unknown a century ago, and the equally revolutionary increase in production facilities have made available such relatively large quantities of these refined alkaloids that they often seem, figuratively as well as literally, "a drug on the market."

In a recent primary market list of about four hundred drugs and fine chemicals commonly used in the United States there were nine alkaloids priced above $20.00 per ounce—more than the price of gold. Tonquin musk and grey ambergris were the only other articles in this list to receive this distinction.

Market prices of alkaloids have shown extreme variations making transactions on the market speculative, rather than business-like.

Arecoline hydrobromide, used in veterinary medicine and derived from areca nuts, was bought and sold in this country during the World War at prices close to $75.00 per ounce. Ten or fifteen years before it had commanded $35.00 per ounce when its use first became generally known to veterinarians. Soon afterwards, as demand increased and production on a larger scale became possible, the price dropped to about $4.00. Now it is about $10.00.

Colchicine, about twenty-five years ago, was bought at more than $50.00 per ounce and is today priced at $20.00.

But it must be emphasized that all alkaloids do not command such prices and that a greater volume of substantial and enduring business rests upon lower-priced alkaloids, such as quinine and its salts (probably among the half-dozen most largely used drugs), than on the alkaloids priced above $20.00 per ounce. In fact, since the total transactions in the high-priced alkaloids is never a large figure in money, the primary drug market reports often group them together under the suggestive title "minor alkaloids."

In the calendar year of 1924, the United States imported about twelve hundred tons of cinchona bark, etc., from which quinine could be extracted and in addition there was brought in about one hundred tons of refined alkaloidal salts, of which two-fifths was quinine sulfate.

No cinchona trees grow inside the United States. About ten tons of these alkaloids were exported.

In 1871, quinine sulfate sold in the American primary market at $2.50 per ounce; in 1891, at 25 cents; in 1914, at 14 cents; in 1918, at 90 cents; now, at about 50 cents. Twenty-six salts of quinine are regularly listed in market reports, some of different degrees of purity and physical condition, such as Dutch, Java, Japanese, U. S. P., etc.

The next largest consumption of alkaloids, so far as weight is concerned, occurs with strychnine and its parent crude, nux vomica. Nux vomica is not grown in this country. In the calendar year 1924, the American market, including some sales for export, required the importation of about 2,300,000 pounds of nux vomica and 99,000 ounces of refined strychnine and its salts. The market price of strychnine has changed from $3.00 per ounce fifty years ago to about 60 cents per ounce now.

Opium and its alkaloids, held under exacting legal restrictions but undoubted medical necessities, are also subjects for important market transactions. In 1871, morphine sulfate was priced in large lots by manufacturers in the United States at $4.80 per ounce; in 1901, at $1.70, and now at about $7.50 per ounce.

It may appear that our citizens have a voracious appetite for alkaloids but in the same period quoted (1924), a single flavoring agent—licorice—was imported in quantities fifteen times as large as were all the more than thirty alkaloidal crudes and the several hundred alkaloidal salts and derivatives added together.

Occurrence of Alkaloids

Experiments in cultivation of alkaloid-containing plants has shown that of two plants, botanically identical and growing side by side, one may develop several times as much alkaloid as the other and this trait may continue through several generations. Here is opportunity for patient investigation over many years.

Less than ten alkaloidal-containing plants are mono-cotyledons; the others are dicotyledons. All plants do not contain alkaloids. A common question about any potent drug from plants is "What alkaloid does it contain?" Many important botanic drugs, digitalis and cascara for example, do not contain alkaloids.

Not much success has come from attempts to show that plants in the same natural orders yield the same or similar alkaloids though it is an attractive field for inquiry. It is not new. After Pelletier and Caventou, in 1820, were successful in isolating quinine, Robiquet reasoned that since the cinchona group in the natural order Rubiacea contained quinine, perhaps it could be extracted from other members of this natural order also. He examined coffee and isolated not quinine but caffeine, quite a different basic substance.

Alkaloids usually localize in the plant. The deposition occurs variously —in the bark in the cinchona tree, in the seed in nux vomica, in the leaves in the jaborandi shrub. In some cases an alkaloid may be found in all parts of its parent plant. Examination of the poison hemlock has shown the alkaloid content of the stem to be 0.064%; of the leaves, 0.187%; of the flowers and flower stalks, 0.236%; and of the immature fruit, 0.5%.

Production of Raw Material

Anatolia, Malatia, Macedonia, and Persia furnish practically all the opium used for the extraction of morphine. None of the opium gathered in British India or China comes to this market for such purposes. Last winter, the Kurdish insurrection against Turkey sent the up-country stocks of opium to the Smyrna and Constantinople markets for safe storage. Makers of morphine salts are much interested in the winter and spring weather in Asia Minor and Persia since sunshine and rain, too little or too much in the poppy fields, will make or mar the annual opium crop and its morphine content.

Compared with year-to-year farmers, the owners of plantations of the perennial cinchona trees in Java, the present center of production, are somewhat independent of seasonal extremes of weather, though weather conditions are by no means a negligible factor in the production of quinine. Uncertainties in politics as well as in weather have often influenced the cinchona and quinine markets. The dealings in cinchona bark were at one time a valued privilege of the Jesuits.

The important supply of coca leaves for the extraction of cocaine hydrochloride is produced by cultivation in Bolivia and Peru. South America also contributes ipecac, the crude from which emetine is extracted, and jaborandi, from which pilocarpine is obtained.

Areca nut (betel nut), yielding arecoline, and calabar bean, yielding physostigmine, are East Indian and African crudes, respectively.

Aconite, belladonna, stramonium, and henbane are some of the European crops, both wild and cultivated plants being collected.

The habitats of hydrastis, lobelia, and stramonium are in the United States. Drug cultivation of alkaloidal crudes in the United States has not reached important proportions though some areas of hydrastis and belladonna have at times developed encouragingly.

Primary Markets for Crudes

The more important world markets for these crudes are in London and Hamburg. Trieste is a primary market for botanicals in Central European and Mediterranean countries. New York City is not so favorably located for direct deliveries from the more important collecting districts but is the center for buying on this continent. The Amsterdam cinchona auctions control the market in quinine and other cinchona salts.

A few British establishments have long been important producers of some alkaloidal salts but the greater variety and quantity came to the United States from German sources prior to the World War. The Germans have not regained the position they had and it is by no means certain that they ever will. Their products were in no way superior.

Caffeine imports in 1914 were 80,000 pounds; only 100 pounds were brought here in 1924. It is to be noted, however, that imports of unclassified minor alkaloids nearly doubled in 1924 over 1923. Favorable tariffs and import regulations are needed by American producers.

American production of cinchona, opium, and nux vomica alkaloids and salts has been important for more than seventy years and lately the minor alkaloids have been produced in sufficient quantities for home consumption.

In late years, Japan has become a source for large supplies of the more important alkaloids and, to some extent, of the minor ones as well.

Important marketing problems have to do with transportation difficulties and uncertainties between the scattered localities wherein are, first, nature's laboratories—the growing plants—for the formation of the alkaloids; second, man's laboratories for their isolation from other plant constituents; and, third, the consuming market places.

Extraction

The crudes are bulky and much manual labor is required in handling them. For many of the alkaloids the total weight consumed yearly does not justify the installation of labor-saving machinery. Moreover, the work must be so closely observed and controlled that mechanical devices do not obviate the need for close attention by a skillful drug chemist at nearly all stages of the work.

In connection with the equipment of establishments producing alkaloidal salts it is of interest to note that a Japanese company, early in 1925, com-

pleted the installation of an air-conditioning equipment costing about a quarter-million dollars. Better ventilation was obtained but, more important, in addition, provision was made for low-temperature manufacturing. Over a hundred patents for a variety of products made to advantage in low-temperature operations are controlled by this company. A few months after this installation was completed, the quinine market had the report that this same company, by the use of low temperatures closely controlled, had made substantial increases in the yield of quinine salts extracted from cinchona bark. Probably no important new discoveries were necessary since the influence of low temperatures on the solubilities of cinchona alkaloids has been closely studied and the results are well known.

Production in non-oxidizing atmospheres or with solvents that do not permit hydrolysis, also, offers inviting opportunities for development.

No single process for extraction or purification applies to all alkaloids. Commercial production usually requires an alcoholic or aqueous extraction of the parent crude; this liquid is concentrated and the alkaloid is extracted with ether or other volatile solvent. The volatile solvent is evaporated and the impure alkaloidal residue is redissolved and precipitated or crystallized. At stages in the work there are added closely controlled quantities of acids to form water-soluble or, perhaps, alcohol-insoluble salts, and alkalies to liberate bases soluble in the volatile solvents.

In some cases the first extraction may be made with acidified water or with milk of lime or other alkali. For volatile alkaloids, distillation may be used. Usually there is uncertainty as to the quality and quantity of the product until the final purification has been accomplished. From one ton of crude stramonium herb, less than four pounds of atropine sulfate, worth at present prices about $45.00 per pound, is an average yield. From one hundred pounds of colchicum seed about five ounces of alkaloid may be obtained. Much larger proportionately are the yields of morphine sulfate (often above 10%), of quinine sulfate from cinchona (at times above 2%), and of strychnine sulfate from nux vomica (more than 1%), but since market prices on these crudes are influenced by alkaloidal content, the maker of alkaloidal salts must, in every case, operate at the greatest possible efficiency to maintain equality with competitors and make production profitable.

Purity

One hundred per cent purity is not constantly maintained in the commercial supplies of alkaloidal salts but the close approach to this point is noteworthy—at least among American producers. Variable quantities of water of crystallization or of adherent moisture may be present; other impurities are not found to a great extent.

Commercial supplies of morphine salts may contain up to one and one-half per cent of other alkaloids, mostly their near relative, codeine; atropine sulfate may contain some hyoscyamine; quinine may show traces of other cinchona alkaloids.

As in the case of other chemicals, melting-point determinations give sharp indications of the purity of alkaloidal salts, especially if the melting points remain constant after reprecipitation or recrystallization and subsequent careful drying.

In some cases, such as cocaine hydrochloride and atropine sulfate, adherent traces of very similar alkaloidal substances may spread the melting point over a number of degrees but if a lower limit be fixed, the determinations give trustworthy indications.

In commercial supplies generally a variation of two to four degrees in melting points of different samples of the same alkaloid, carefully dried but not repurified, is ignored.

In toxicological work, attention has been given to the sublimation of alkaloids. As a rule, temperatures much higher than the melting points cause decomposition but in the case of caffeine, sublimation occurs so readily that use of this characteristic has been made in its extraction from whole coffee berry. This is one reason for roasting coffee in closed containers.

Tests for Purity and Identity

The optical activity of alkaloids has been found very useful in purity and identity tests.

Absolutely trustworthy simple tests for the certain identification of single alkaloids are not numerous.

Color tests have held a prominent place for such purposes as well as in tests for purity but little reliance is now placed upon them unless confirmatory evidence can be had from solubility, melting point, and optical activity determinations and from the known history of the sample.

Physiological tests are often useful also. The highly toxic aconitine, in very dilute watery solutions, benumbs nerve endings. Quantitative tests may be used on this property. Identification of the atropine group involves tests on its power of dilating the pupil of the eye.

Form of Alkaloid Employed

The alkaloidal salts, such as the sulfate, salicylate, etc., are much more generally used than are the basic substances themselves. In these salts the influence of the alkaloidal base predominates over the acid.

Because the salts, with few exceptions, are more soluble in water, they are more conveniently used in medicine and are probably more quickly and certainly active after administration.

Physostigmine sulfate is very hygroscopic but the salicylate, only slightly so, is preferred for use.

Except in the precise writings on chemistry and pharmacy, the title morphine is frequently used when morphine sulfate would be correct; quinine, likewise, often should read quinine sulfate.

Synthesis

Research on the molecular structure of alkaloids has shown that this class name has been used for derivatives of pyridin, pyrrolidin, tropein, quinoline, isoquinoline, phenanthrene, and iminazole rings. As a matter of convenience most writers do not exclude from this class the purin group—caffeine and theobromine.

While the molecular structure of nearly all the alkaloids is understood, it must be admitted that, even in the case of some of those most thoroughly studied, some details are lacking. Complete proof of the claimed structure by synthesis is also lacking in some important instances.

The synthesis of cocaine hydrochloride has been patented but the two American laboratories from which this alkaloid is marketed depend on the importation of crudes from South American sources.

Caffeine was synthesized in 1895 but coffee remains an important source of supply. The synthetic production of morphine has not been accomplished. Morphine, codeine, and thebaine, all derived from opium, are phenanthrene derivatives. Their structure is understood in nearly all details. Codeine has been produced by methylating morphine; thebaine may be made into codeine by passing through the ketone, codeinone. Long, continued investigations on the molecular structure of atropine and hyoscyamine have resulted in a satisfactory synthesis but such production is commercially disadvantageous.

Plants furnish alkaloids with incomparably less trouble and at less cost than man can do. Nature's process for production and man's for isolation and purification has to date been the most advantageous combination.

Outgrowths of Alkaloid Investigations

But though the direct commercial advantage from studies on the synthesis of alkaloids lies in the future, science has taken an immediate profit from these researches. Closely linked with them has been the synthesis of an immense number of compounds more or less distantly related to the alkaloids and, in many instances, of much practical use in medicine and industry.

The first organic dye, mauve, was discovered in an attempt to synthesize quinine. Just as the isolation of alkaloids from plants was the great achievement of the early years of the last century, the introduction of many useful organic compounds produced artificially was the great ac-

complishment of the later years of the nineteenth century. We have not yet stepped forward into another zone of such distinctive character.

Some synthetic derivatives of alkaloids are largely used in medicine. Diacetyl morphine and its hydrochloride, also known commercially as heroin (in allusion to its extreme potency—a heroic property) has been probably the most largely used in this class. One of the earliest known synthetic derivatives of morphine is apomorphine, formed when the morphine molecule is dehydrated by treatment with hydrochloric acid. Apomorphine is the quickest, most certain, and least irritating emetic known to medicine but our laws look upon it as a habit-forming drug, of which the purchases and sales must be reported to the government.

Studies on the constitution of cocaine had a direct bearing on discoveries of a number of new compounds having anaesthetic effects when applied to nerve endings. The action of none of these exactly parallels cocaine which is probably used more largely than any of the newer compounds.

Physiological Effects

Medicine calls for larger quantities of alkaloids than any other field of use. Generally speaking, the physiological activities of individual alkaloids may be said to be the blocks from which is built the total physiological activity of the parent crudes.

In the many instances where more than one alkaloid are contained in a single crude plant product, these alkaloids when isolated and studied separately may show very different physiological effects. Thus of the four alkaloids derived from areca nut, one is reported physiologically inert, two are non-poisonous, and the most important, arecoline, administered to the horse is a powerful stimulant of peristalsis in doses of as little as 30 mg. ($^1/_2$ grn.).

Quinidine, isomeric with quinine, has received no preference in medicine except for its effect in auricular fibrillation of the heart. For this condition, the parent crude, cinchona, is useless since its quinidine content is completely masked by cinchonine, quinine, etc., none of which parallel quinidine in its cardiac effect.

Derosne, a French manufacturing pharmacist following suggestions of Vauquelin in 1803, separated a crystalline substance from opium. Animal experimentation seemed at times to indicate that these crystals were the long-sought, active ingredient. Now it is believed that Derosne's salt was the alkaloid we know as narcotine or mixtures of this with small proportions of morphine. During the next thirteen years until 1816, Serturner in Hanover, working over the same ground, did separate opium's most active ingredient, morphine, and being misled by the comparative harmlessness of Derosne's salt, nearly lost his life in several experiments with the newly discovered potent morphine. The pharmacopoeial adult

dose of morphine sulfate is 8 mg.; narcotine may be given in doses of 650 mg.

As isolated alkaloids have been studied pharmacologically they have usually taken a place for themselves—not displacing the parent crude from use.

Non-Medicinal Uses

Happily, the days of professional poisoners have passed but the production of strychnine on its present scale depends largely on its use as a poison for rodents. When Western land was coming under cultivation, strychnine was used freely to reduce the numbers of prairie dogs, ground squirrels, chipmunks, rats, and other crop-destroying animals.

This use continues in limited territories. Very large quantities of strychnine and its parent crude, nux vomica, have been used in veterinary medicine. Some alkaloids have been used in the synthesis of other chemicals, as narcotine in the synthesis of vanillin, but it is not commercially advantageous to do so.

Quinine sulfate and some similar alkaloids are used as denaturants for ethyl alcohol for certain limited purposes in the United States and this demand, at times, is of importance on the market.

What to do with the by-products, or more correctly, with the associated alkaloids from the same crude, is a question in the commercial production of any largely used alkaloid. When morphine sulfate is made from opium, codeine salts also become available. It practically never happens that the market demand for these two articles is exactly proportional in the ratio present in the crude drug. Strychnine and brucine are found in about the same percentages in nux vomica but there is only a trifling market demand for brucine and a much larger one for strychnine. Both hydrastine and berberine exist in hydrastis but again the relation between the market demands never parallels that between the percentages found in the crude.

Drug Regulation

To prevent drug addiction, nearly all nations have enacted laws restricting commerce in the alkaloids derived from opium and coca leaves. A considerable body of international, as well as national, discussions and agreements has grown around this subject.

In the United States, purchases or sales of morphine, cocaine, etc., are reported to the federal authorities and in many states to state authorities also. Physicians' prescriptions are open to the officers of the law. Since early in 1924, the diacetyl derivative of morphine cannot be made legally or be imported into the United States. When the quantities in stock are consumed, it will not be available for medicinal use. In the case of opium alkaloids, greater exertion has been made in recent years to

discourage or prevent their production than was made a hundred years ago to discover them.

All effective limitations on the harmful use of these narcotic drugs have originated with reputable dealers and producers who, likewise, have been the mainstay of the enforcement of these laws. No responsible and informed person places the total number of drug addicts in the United States at more than one in seven hundred population, and careful estimates, based on the quantities of habit-forming drugs obtainable, justify the statement that one addict per one thousand of population is the maximum number. A minimum estimate is one per two thousand of population. The number has steadily decreased in the last twenty years.

Assay Methods

Not the least important advance brought about by the isolation of alkaloids was the development of assay methods and the fixing of standards for many important medicinal preparations. The impetus thus given to accuracy and uniformity in medicine has been beneficial to humanity beyond calculation. The patient, with his whims, idiosyncracies, and defects, can supply more than enough uncertainty to medical practice. To the physician these are uncontrollable variants. It is greatly to be desired that the other factor—the remedial agent—should not be variable. Though much has been accomplished in devising and applying these methods, very much remains to be done.

Standards for two alkaloidal, crude drugs were given in the fifth (1870) United States Pharmacopoeia. To these were added, in 1894, standards and assay processes for extract of nux vomica and for the tincture and extract of opium. Such standards have been required for other crude drugs and preparations in succeeding editions until the tenth edition, soon to become official, numbers nearly forty such instances. Half as many more are in the National Formulary and in the Methods of the Association of Official Agricultural Chemists.

Standards

Commercial practices have often been in advance of legal practices in the adoption of standards for alkaloidal drugs and preparations. The number and variety of such standardized preparations offered on the drug market much exceed those in the United States Pharmacopoeia and National Formulary. Acting under the authority of the Food and Drugs Act, the federal drug authorities of the Bureau of Chemistry together with committees from associations of pharmaceutical manufacturers have recently formulated assay processes and standards for a number of preparations for which no legal standards have heretofore been in effect.

The pharmacopoeia gives four pages to a resumé of alkaloidal assays,

proximate assays being the chapter heading. Only the underlying principles and more important precautions are described. In all published methods much is left to the preference of the operator. Great variations in samples make necessary methods of much elasticity. Experience is necessary for accurate results. The pitfalls are many.

Most of the methods are volumetric; in many cases the quantity of alkaloidal base in the weighed or measured sample is less than 50 mg. to which two hundred times as much of a great variety of other substances is adherent. In the official hyoscyamus assay it is expected that 16 mg. of alkaloid will be found in 25 g. of crude (1:1500); an excess or deficiency of one drop of volumetric solution may make an error of large proportions. Yet notwithstanding these difficulties, findings by different experienced drug analysts on the same sample may be expected to be within 2% of an average under the most favorable circumstances. In commercial practice no serious objection is made to findings within 5% of an average.

These assays are a part of the routine control work of some thirty-five pharmaceutical manufacturing establishments in this country to which may be added the several drug laboratories of the Bureau of Chemistry of the U. S. Department of Agriculture and also those maintained by the state drug officials. Laboratories in colleges of medicine and pharmacy are also equipped to do this same work.

The Literature

Very many reports on the results of research on alkaloids appear at intervals in chemical journals and in pharmaceutical publications. A large volume of such literature has appeared.

In book form, the following give comprehensive descriptions on various parts of the subject:

T. A. HENRY: *The Plant Alkaloids.*
A. PICTET, translation by H. C. BIDDLE: *The Vegetable Alkaloids.*
ALLEN'S *Commercial Organic Analysis; volumes 6 and 7.*
BLYTH'S *Poisons—Their Effect and Detection.*
The United States Pharmacopoeia; the tenth and earlier editions.
The National Formulary.
Methods of the Association of Official Agricultural Chemists.
WOOTTON'S *Chronicles of Pharmacy.*

Opportunities Remaining

There are yet very many unanswered chemical questions concerning these alkaloids that only painstaking and long, continued investigations will answer. Some of these questions concern the alkaloid in the growing plant, some in the dried, crude plant product, some after it has been administered as medicine.

Who will find the way to modify the molecular structure to remove the

bitter taste with little or no disturbance to the beneficial properties—or to eliminate other undesirable qualities?

Ample opportunities remain yet for those now engaged in these investigations and for their successors to make notable and helpful additions to our information concerning alkaloids.

Carbon Melts and We May All Wear Diamonds. The long-sought-after process of melting carbon, whose lack has stood in the way of the manufacture of genuine diamonds, has been discovered by a group of German chemists, Drs. Alterthum, Fehse, and Pirani. Carbon has been one of the most heat-resistant substances known, and for that reason it has been used in arc lights and carbon filament lamps where a powerful current sent through this substance found such resistance that it raised it to white heat without melting.

But the existence of diamonds which are pure crystallized carbon tantalized chemists for years, because it proved that at some time in the past carbon had been in a molten state before it formed the transparent eight-faced diamond crystal. Graphite has been known for a long time and can be made artificially, but unlike the diamond, it is softer, opaque, and forms six-faced crystals.

Dr. Alterthum and his co-workers heated a graphite cylinder about five and a half inches in length and an inch and a half in diameter, the thickened ends of which were set in copper electrodes, by means of an electric current. The various temperatures attained were measured at the middle of the cylinder through an opening. It was definitely determined that some degree of melting actually occurred within the bore of the carbon cylinder, and the melting point was determined as about 6300 degrees Fahrenheit.—*Science Service*

Smelter Eliminated in New Minnesota Iron Process. A process eliminating the smelter from the process of changing iron ore into steel and employing the direct reduction process of iron ore to iron without smelting has succeeded in American laboratories, is now in use by a company at Oviedo, Spain, and is being perfected at the University of Minnesota Mines Experiment Station with a view to its introduction at the Northern Minnesota mines.

Low grade ore, containing 30 to 45 per cent iron, and low-grade fuel, such as North Dakota lignite, can be used in the process, according to specialists at the Minnesota station. Large savings will be effected, first, by using the cheap fuel, and second, by eliminating the shipment of the large percentage of waste matter that must be moved as part of low grade iron ore.

The ore is placed in one end of a long, rotating tube and the fuel, in gasified form, is forced into the other. A temperature of 1800 degrees Fahrenheit is maintained, and air is excluded. The fuel burns by combination with the oxygen of the ore. When combustion has been completed only silica remains as a foreign substance, mixed with the metallic iron, and the iron is separated from the silica by magnetism or some other physical process. The temperature at which this takes place is not sufficient to melt the ore, and it is unchanged in structure when taken out, although its color has changed from red to black. The metallic iron is then agglomerated into briquets by pressing, so that it will be easier to handle.

It is claimed that perfection of the process on a commercial scale will provide the most important method yet developed of utilizing the low grade ore of the Minnesota and Michigan ranges, estimated to exceed 1,000,000,000 tons, of which almost none is now used in the iron and steel industry.—*Science Service*

THE ANTIOCH PLAN OF COÖPERATIVE EDUCATION AS IT AFFECTS STUDENTS IN CHEMISTRY*

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The Antioch Plan
Required Courses
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What the Antioch Plan Accomplishes

By way of introduction it may be appropriate to say a few words in regard to Antioch College and the plan which has created so much interest in the educational field, the plan which President Eliot of Harvard has declared to be "the most significant experiment now going on in American education."

Antioch College

Antioch College, located at Yellow Springs, Ohio, is one of the older colleges of the state. The college was founded in 1853. Horace Mann, a pioneer in American education, became the first president of the college. Four years ago the college was reorganized by Arthur E. Morgan, and, as in the case of Horace Mann, he instituted a departure from the prevailing ideas and traditions of contemporary education in the form of the Antioch Plan of Coöperative Education. The coöperative plan had previously been used by Dean Herman Schneider, of the University of Cincinnati, in connection with the engineering course of that institution, but Mr. Morgan was the first to apply it to the general field of education.

Some general facts about Antioch College may interest the reader. Antioch is not a denominational institution. The college is coeducational. The enrolment is limited to six hundred students, of whom twenty-five per cent are girls. The college has a beautiful campus of three hundred acres. The students are carefully selected, about one out of three or four applications being accepted. There are approximately 150 individual employers of Antioch students.

The Antioch Plan

Upon entering the college, the new coöperative student is assigned to one of two divisions, A or B. These divisions alternate with each other in five-week shifts between academic work at school and economic work outside. A single job is held throughout the year by two students. The school year for each division is twenty weeks. The coöperative work ordinarily requires six years for graduation, but many students are able to complete the work in five years. So far as it is possible the student is employed in the calling for which he is preparing himself. The chief reason

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for this part-time work is its educational value, although it helps to provide a means of partial self support.

The purpose of the coöperative plan, expressed in Mr. Morgan's own words, "is to bring about a balanced development of character, intelligence, and power; to correct prevailing disproportionate emphasis upon elements of personality or of environment; to give the student a liberal college education, vocational training, and apprenticeship to practical life."

The college is therefore interested in the symmetrical development of the student. It is interested in the whole of the personality rather than a part. It attempts to train generalists and not specialists; to combine experience with books. The student learns about life while at school and experiences life itself on the job. Judgment, common sense, intuition, and self-reliance grow and develop more rapidly under the plan, for these qualities grow best when in contact with real life.

Required Courses

All Antioch students must take the required liberal courses which include one year of mathematics, physics, chemistry, biology, earth science (geology and astronomy), hygiene, psychology, philosophy, and legal principles; two years of literature and four years of social science (economics and a general survey course in history).

All regular Antioch students are required to take one year of college chemistry regardless of whether or not they have had high-school chemistry. We feel that Antioch is a pioneer in being among the first to make such a requirement in a liberal arts college, and to recognize the importance of chemistry as a cultural subject and a necessary part of a general education. This requirement places chemistry on the same basis as literature and history as cultural subjects. Chemistry has come into its own at Antioch, being recognized not only for its value as a tool-subject in some profession but also because of its educational value.

Only those who have taken adequate courses in chemistry, physics, biology, geology, and the other related natural sciences, can appreciate the satisfaction, confidence, and increased capacity for the enjoyment of life that comes in the intelligent and scientific interpretation of the composition and phenomena of our physical universe. We live in a material world; we move about in a material environment; we are dependent upon material things for our food, clothing, and livelihood. It is essential therefore, in this day and age of intellectual and economic competition, that every student be made acquainted with the essential facts of chemistry and the other natural sciences. The Antioch program recognizes this necessity.

Courses in Chemistry

There are two courses in freshman chemistry. The first is a technical course, designed for those students who are technically inclined and who

expect some day to become pure scientists, engineers, nurses, doctors, students in specialized home economics, and the allied professions. This course is of two years' duration. There are two lectures, one quiz, and one three-hour laboratory period per week the first year. In the second year two three-hour laboratory periods and the regular class-room work are required. The laboratory work in the first year includes the conventional experiments in freshman chemistry. The introduction of more quantitative and physical chemistry experiments, such as molecular weight determinations (freezing point, boiling point, etc.), is contemplated for the coming school year. The laboratory work during the second year includes a rather comprehensive course in qualitative analysis. Because of the discrimination exercised in the selection of students by the college, it has been found advisable and feasible to include in the course more mathematics and inorganic physical chemistry than is ordinarily done in the conventional college course in freshman chemistry. Chapters in Cartledge's "Inorganic Physical Chemistry" and Getman's "Theoretical Chemistry" are assigned to the students. The text-book used in this course is McPherson and Henderson's "General College Chemistry," supplemented by Evan's "Study Outline." Both those students who have had and those who have not had high-school chemistry are enrolled in this course. The results of the past four years clearly indicate that this is practicable.

The other course in freshman chemistry, which is required of all those students not taking the technical course, is designed to place more emphasis on cultural considerations. The course is of one year's duration. There are three lectures, one quiz, and one three-hour laboratory period per week.

Students interested in journalism, law, ministry, literature, business, and allied professions automatically take this course unless they express a preference for the technical course. The writer has been particularly interested in the development of this course. It offers an opportunity to sell chemistry to a class of students who, in many colleges, would not be required to take any chemistry. Some of these students also have certain preconceived prejudices and unwarranted doubts as to the value of chemistry in a general education. These converts are worth working for. The high-school training of many of these students has not prepared them for the study of science. Many, therefore, lack the potentiality and background for developing technical concepts. Such an opportunity, however, offers a real challenge to the teacher, and requires real pedagogical ability. If we could do more missionary work among students of this class, we could eliminate, in the future, much of the bigotry and narrow-mindedness so often exhibited in the fields of religion, economics, and politics.

Objectives and Methods

The object of this cultural course is to give the student a point of view and perspective of the field of chemistry as it is applied to everyday life. It is hoped that the course will help the student develop a confidence in the endurance of the laws of creation; that it will encourage a curiosity as regards the composition of material things; that he may come to appreciate the importance of chemistry in the industrial achievements of the human race; that it may equip him with enough chemical facts to enable him to discuss intelligently the more elementary chemical phenomena. The writer has found such questions as the following stimulating and helpful in developing a chemical curiosity and in inducing the student to think about chemistry outside the class-room:

"Looking at a landscape from a chemical point of view; what do you see?"

"What chemical processes, elements, and changes of composition are suggested to your mind when you look at a book, a wooden table, a bird, the steam heater in the laboratory, the electric light bulb, one's clothes, an automobile, a brick wall, etc.?"

"Catalog the chemical industries suggested by the material objects you encounter in a single day from the time you get up in the morning until you retire at night."

The course differs from the conventional college course in the emphasis placed upon certain topics in general chemistry. For instance, much more time is spent in a discussion of the personalities and events which make up the history of chemistry. The principal laws and theories of chemistry are stressed only in so far as they enable the student to understand and handle the chemical equation. Considerable time is spent upon the periodic law and its suggestion of inorganic evolution. A little philosophizing is indulged in at this point. Approximately one-third of the year is given over to the study of organic chemistry. During the course of the year the students read, in the form of reference assignments, the following books: Moore's "History of Chemistry," Slosson's "Creative Chemistry," Geoffrey Martin's "Modern Chemistry and Its Wonders," Geer's "The Reign of Rubber," and "Chemistry in Industry," by H. E. Howe. While this course, of necessity, is much more descriptive and superficial than the technical course, the writer has attempted to maintain a balance between the descriptive matter, which is obtained largely through outside readings, and the theoretical work, which is confined largely to the lectures. Although this course has only been on trial for three years, it has, so far, proved well adapted to the class of students to whom it is given.

The other regular courses in chemistry at Antioch include quantitative analysis, which is made a one-year course with two lectures and two three-

hour laboratory periods per week; organic chemistry and physical chemistry, both of which are two-year courses, accompanied by laboratory work.

Autonomous Study

The Antioch Plan also includes the idea of autonomous courses. A student who has shown proficiency and initiative along certain lines, may, with the consent of the instructor, pursue a course by himself much as graduate students do in our larger institutions. In general, no student is allowed to take autonomous work in a department unless he has taken all the introductory courses in that department, receiving an average grade of "B." It has been gratifying to the writer to note the number of accomplished students who have accepted this challenge of autonomous courses and made good.

Part-Time Work

The part-time work for students interested in chemistry is managed in the following way:

The college endeavors to place those students interested in chemistry in industries where they will have an opportunity to make first-hand observations of chemical processes. Among the chemical industries which are employing Antioch students are the Dayton Rubber Company, Dayton, Ohio; General Motors Research Corporation, Dayton, Ohio; Sun Oil Company, Toledo, Ohio; Eli Lilly Company, Indianapolis, Indiana; the coke plant of the Inland Steel Company, Indiana Harbor, Indiana; Ashland By-Products Coke Company, Ashland, Kentucky; Du Pont de Nemours Company, Wilmington, Delaware; American Rolling Mill Company, Middletown, Ohio; and the Hooven and Allison Company, Xenia, Ohio.

The nature of the jobs range from that of laboratory "wash boy" to routine analysis and practical research. Many are engaged in production. Whether the student's job be that of a wash boy in a laboratory or of a research worker he is encouraged to study the organization of the factory and to observe the chemical changes through which the raw material passes until it reaches the finished product. Such students have a first-hand knowledge of chemical processes that chemical text-books will never be able to give them. The students always return from their jobs with a variety of chemical problems which they are eager to work out.

Advantages of Part-Time Work

Chemistry, to them, is not just a subject to be studied and passed, but a real, living, vital, fundamental science essential, in all of its applications, to the future welfare of the world.

Students who, perchance, are interested in chemistry as a pure science,

are at first placed on chemical jobs in the industry and are later transferred to the college chemistry laboratory where they serve as assistants.

It is not always feasible and practical to place students on research jobs because of the very nature of research. The Antioch plan is sufficiently elastic, however, so that students engaged in industrial research can alternate every ten weeks instead of five.

The part-time work on chemical jobs allows a gradual approach to one's calling and helps to eliminate blind guess-work in choosing an occupation. If the student finds that he is not interested in, and fitted for, chemistry as it is being practiced either in the industry or laboratory, he has the opportunity of changing his course before it is too late. No greater tragedy can come to a college graduate than the realization that he is a misfit in the calling for which he has prepared himself.

The part-time work, furthermore, affords a means of partial self-support. The student is not worried about financial difficulties while at college because he has got that problem out of the way while on his job. He can, therefore, give his undivided attention to his studies. Financial worries handicap many college students.

The student is also in a position, during his industrial life, to make intelligent and understanding observations on that vital problem in world industry, capital, and labor.

The Employers' Viewpoint

The industries are interested in Antioch students because they can get intelligent and ambitious help at a reasonable wage. It is not a philanthropic or sentimental enterprise on the part of the industry. It is purely a business proposition. The college asks for no concessions on the part of the industry. The salvation of the Antioch plan depends upon this attitude. The student must compete with his fellow employee. It is imperative that the part-time work be real life with all of its battles.

Antioch students, selected from forty-one states and ten foreign countries (twenty-eight per cent from Ohio), working in eleven states with one hundred and fifty employers, are helping to bridge the gap between theory and practice. Industries find the students good investments.

Liberal Education for Chemists

I believe that most people will agree that there is a growing necessity for a liberal education on the part of our future chemists. The specialist, the product of a narrow technical education, is not in demand today as compared with the generalist, the product of a liberal education. It is more difficult to find the director of a research laboratory than to find a "researcher."

There is no limit to the growth of a chemist with a broad, liberal educa-

tion, but the specialist without such a background finds that very soon he has reached his limit, beyond which he cannot go without broadening his foundation. The realization of this limit sends many graduate chemists back to college where you will find them taking courses in legal principles, English, economics, social science, business administration, etc. When we study the lives of the world's greatest chemists and our great chemical executives we find that they have either been liberally trained, later to develop their specialties, or have attained a liberal and cultural foundation afterward through their own initiative.

In this sense it is felt that the six years spent at Antioch tends to develop habits of liberal and cultural interests more permanently than three or four years at other colleges. Mr. Morgan believes, as was mentioned above, that the whole of personality is worth more than its parts and that the student should have the opportunity of seeing life as a whole instead of that afforded by the limited facilities of a college environment.

Interruptions No Disadvantage

Many questions have been asked about the possible interruptions to the sequence of the course due to change of divisions at the time of the five-week shift. The writer himself anticipated such an interruption. However, the actual practice of the plan has proved that such interruption is negligible, and even has certain advantages for the student. Thus he has an opportunity of reviewing and also applying and living the things which he has been taught during the preceding five weeks of study. When the students return to school the next lecture in the course is given. The students learn by experience to expect this and prepare for it. The work in industry often gives them something to which to tie their chemistry.

What the Antioch Plan Accomplishes

Instead of the isolated, artificial, unlifelike conditions so often characteristic of the average college environment, the Antioch plan of cooperative education puts in its place real, tangible life with all of its battles. The students learn by actual experience how much life costs in labor, and return from their five weeks on the job with a seriousness of purpose and a renewed energy for scholastic work which is unmistakable.

The Antioch plan of coöperative education is helping to bridge the gap between college and industry, the problem so often discussed in the columns of our chemical journals. Although the plan has been in operation but four years it has demonstrated that it has certain intrinsic merits which are worth preserving. As in the case of any pioneer enterprise it has met many obstacles. Thanks to the perseverance of Mr. Morgan and his friends, the Antioch plan of coöperative education promises to play an important part in American education.

THE CHEMICAL NATURE OF THE COLLOIDAL SOIL MATERIAL

P. L. GILE, U. S. BUREAU OF SOILS, WASHINGTON, D. C.

Soil Structure
Chemical Character of Soil Colloids
Differences in Chemical Composition
Difficulties in Analysis
Unanswered Questions
Physical Properties

Not many years ago soil colloids were described as a sink for half-baked theories of the physical and chemical properties of soils. There was some truth in this. Soil properties which could not be fully explained by conceiving of the soil as a mixture of discrete mineral particles bathed by a dilute salt solution, were ascribed to the modifying influence of some special compounds of a zeolite-like or colloidal nature, without a very definite idea of what this material was.

At present, however, it is no longer good form, even among the more conservative, to dismiss the colloidal soil material with the aphorism that it is a sink for what we do not know. Modern advances in colloid chemistry have explained many of the mysteries of what Ostwald ten years ago called "Die Welt der vernachlässigten Dimensionen." Moreover, recent investigations conducted on the colloidal soil material itself, isolated from the rest of the soil, have shown the large quantities present in the soil and have disclosed something of the chemical nature and properties of the material.

Soil Structure

The colloidal material in the soil is intimately mixed with non-colloidal mineral particles. Some of it adheres to the coarser particles and some of it forms aggregates which appear similar to discrete mineral particles. Usually 20 to 25 per cent of colloid is present in loam soils and 40 per cent in clays (5).* A few soils have been examined with 90 per cent or more colloid. Only a very small part of the colloidal material passes into the sol condition on simply mixing the soil with water (2). This is a disadvantage for the soil investigator but is a fortunate circumstance for the rest of the human race.

The colloidal soil material may be regarded as a distinctive part of the soil, not only because it is made up of submicroscopic particles, but also because it differs from the rest of the soil in chemical composition. Even if the colloidal material were of the same chemical nature as the larger soil particles, it would still be considered colloidal because of the small size of its particles. It just happens, however, that the soil colloidal material is, preponderantly at least, of a different chemical nature from the silt and sand grains.

Chemical Character of Soil Colloids

Considering the diverse origins of the colloidal material and of the coarser soil particles, it is obvious that these two classes of material should

* Reference is made by number to literature cited at the end of this article.

differ in gross chemical composition. The coarser particles of the soil are fragments of quartz, hornblendes, feldspars, micas and other minerals. Most of these minerals were formed under igneous conditions and are unstable in water. The colloidal material on the other hand, is no doubt made up chiefly of disintegration products of these minerals. It might be regarded as the insoluble precipitate resulting from reactions between soil water and silicate minerals.

As a rule the colloidal material contains only one-half as much silica and several times as much iron and alumina as the usual mixture of minerals forming the larger soil particles. Of course, the difference between minerals and colloids varies more or less widely according to the character of the minerals in the parent soil material and according to the maturity of the soil.

The character of the colloidal material that may be present in different soils is shown in Table I. These analyses were selected with a view to illustrating some of the variations that the Bureau of Soils has encountered in colloidal materials isolated from seventy soil samples.

TABLE I

CHEMICAL COMPOSITION OF COLLOIDAL MATERIAL ISOLATED FROM VARIOUS SOIL TYPES

(Analyses by Messrs. Robinson, Holmes, Mattson, and Denison, Bureau of Soils, U. S. D. A.)

Soil type	Locality	SiO_2 Per cent	TiO_2 Per cent	Al_2O_3 Per cent	Fe_2O_3 Per cent	MnO Per cent	CaO Per cent	MgO Per cent	K_2O Per cent	Na_2O Per cent	P_2O_5 Per cent	Organic matter Per cent	Combined H_2O Per cent
Fallon loam, soil	Nevada	50.49	0.51	16.73	10.77	0.121	2.36	5.32	2.24	0.54	0.37	1.79	8.26
Sharkey clay, soil	Mississippi	50.13	.46	21.70	8.70	.035	1.48	2.54	1.86	.24	.69	3.83	8.73
Stockton clay adobe, subsoil	California	49.50	1.14	22.51	10.57	.023	1.96	2.68	0.26	.66	.06	1.20	10.75
Marshall silt loam, soil	Nebraska	44.94	0.47	22.15	8.91	.126	1.12	1.95	2.07	.19	.70	7.94	8.92
Carrington loam, subsoil	Iowa	48.04	.65	25.19	8.80	.032	1.29	1.53	0.89	.38	.14	4.52	9.23
Ontario loam, subsoil	New York	42.40	.56	24.71	15.27	.138	1.18	2.59	2.39	.51	.25	3.49	7.22
Sassafras silt loam, subsoil	Maryland	41.14	.70	29.26	12.73	.031	0.53	1.07	1.35	.42	.08	1.59	12.49
Sassafras silt loam, soil	Maryland	39.24	.63	28.64	10.19	.123	.75	1.16	1.17	.38	.47	6.32	10.97
Vega Baja clay loam, soil	Porto Rico	36.26	.65	32.85	12.44	.160	.44	0.18	0.36	.47	.36	4.15	12.73
Cecil loamy fine sand, soil	Georgia	31.30	1.01	33.64	11.66	.07	.56	.78	1.71	.58	.24	6.33	11.79
Aragon clay deep subsoil	Costa Rica	15.86	3.54	34.38	22.67	.068	.21	.29	0.27	.33	.26	5.96	15.63

These few analyses are sufficient to show the wide variations that may obtain in colloidal materials of different soils. The other side of the case, the constancy of the composition of colloids from different soils, is not shown in the table. It is evident, however, from analyses which have been made by Robinson and Holmes (7) and by Bradfield (3) that quite different soil types may yield colloids of very similar composition.

Differences in Chemical Composition

Why the colloidal materials of some soils are similar in composition and the colloids of other soils are different, is a broad field for investigation. Since the soil colloids are chiefly the disintegration products of minerals, we naturally look to what is known of rock weathering for an explanation of their compositions. It should be borne in mind, however, that even the colloidal material is not a stable end-product of mineral decay. The material is doubtless changing in composition under the influence of soil processes. So a study of the composition of the different soil colloids becomes in the end a study of the processes of soil development.

It is apparent from any one of the analyses that the colloidal soil material is decidedly a mixture. Ten elements are present in determinable quantities besides organic matter and water held at 110°C. Some of the elements, as sodium manganese, titanium, and calcium are usually present in small quantities. But they seem to be present in the colloids from all soils; hence they are a characteristic part of the material just as much as the major constituents, silica, alumina, and iron.

Difficulties in Analysis

Owing to the fact that the bulk of the colloidal material in most soils seems to be made up of particles which are only about 0.1 of a micron in diameter, no very conclusive proof has been offered of the exact form in which the different elements are present. X-ray examination, made by Dr. Wyckoff of the Geophysical Laboratory of the Carnegie Institution of Washington, indicates that some crystalline material is present. It is therefore evident that a definite compound, or compounds, of some sort forms at least part of the colloidal material.

The usual analytical methods throw very little light on the condition of the elements in the colloidal material. Treatment with dilute acids or dilute alkalies dissolves considerable of the different colloids but the composition of the solutions is on the whole no simpler or more definite than that of the untreated material. This is also true of the residues undecomposed by the acids or alkalies. The solubility, or decomposability, of the material therefore gives no evidence as to whether the chief constituents, silica, alumina, and iron, are mainly present as oxides or as silicates.

Unanswered Questions

The question of whether the silicon, aluminum, and iron exist in the colloid as silicates or as oxides apparently cannot be decided satisfactorily by general considerations. In favor of the oxide hypothesis might be cited: the variable proportion of silicon to aluminum and iron in the different colloids; the strong tendency to hydrolysis of silicates and of aluminum and iron salts; and the occurrence of natural deposits of silicon, aluminum, and iron oxides which were evidently formed by weathering. On the other hand, the occurrence of such minerals as kaolinite, pyrophillite, and allophane, which are evidently secondary products of rock weathering, might be taken as evidence of a tendency of silicon and aluminum to combine under certain natural conditions.

More direct evidence is available concerning the condition of the calcium, magnesium, and potassium in the colloid. It has been found by Mattson (6) that when the colloidal material is subjected to electro-dialysis, or is treated with neutral salt solutions, practically all the calcium is removed and a small part of the magnesium and potassium, but practically none of the other constituents. The portion of the elements which exchange with the bases of neutral salt solutions may be regarded as held in the colloid in an adsorbed condition.

Physical Properties

Even if all the compounds present in the colloidal material were known, many of the properties of the material would still remain unexplained. A high heat of wetting or a low capacity for adsorbing vapors would not necessarily be explained by the presence of aluminum oxide or of aluminum silicate, since these properties are presumably dependent largely on structure. However, it has been pointed out by Anderson and Mattson (1) that the properties of the different colloids correlate fairly well with the gross chemical compositions of the material, so structure and chemical composition are probably related (4).

With due regard for what is and is not known, the soil colloidal material may be regarded as a mixed gel, made up chiefly of silicates, oxides or both, with the possibility of many compounds being present in small amounts. The constituents may be partly or wholly in a crystalline condition or partly amorphous. Most of the calcium, and part of the magnesium, potassium, and sodium appear to be present in an adsorbed condition.

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Many Can't Name Work They Like. That it is very difficult for the average individual to select the kind of work in which he has most interest, is shown in a report by Douglas Fryer, professor of psychology in New York University, which will appear in a coming issue of the *Journal of Applied Psychology*.

When a person is hunting a job it would seem that he should know what kind of work, in general at least, he is most interested in doing. However, among more than 200 applicants in a vocational office in New York City scarcely one was really able to select the kind of work that held the most interest for him.

In attempting to find the kind of work in which the applicant was likely to be most interested, work was divided into two general classes, humanics, or work with people, and mechanics, or work with things.

Humanics was divided into concrete humanics, or work directly with people, influencing, advising, directing people like the buyer, the salesman, the executive; and abstract humanics, or work indirectly with people, promoting and forming policies, ideals, and organizations for people to work or live by, like the publicity man, the advertising man, the advertising writer, the journalist.

Mechanics was divided similarly, concrete mechanics or manipulating tools and machinery, dealing with the things themselves, like the work of mechanic, the construction worker, the farmer, and a great deal of the work of the engineer; and abstract mechanics, or work with languages and figures, dealing with the symbols of things, like the work of the accountant or bookkeeper, the draftsman, and the bank teller.—*Science Service*

Finds Hydrogen Tides on Remote Star. What is that distant sun, known to astronomers as Kappa Draconis, doing with its hydrogen? Dr. Otto Struve, of Kerkes Observatory, brought this question before his colleagues recently, at the meeting of the American Astronomical Society. He has not found the answer yet himself; all he has discovered is that at times this inconspicuous member of the stellar universe seems to have plenty of the lightest of the elements, and after the lapse of a number of years that the hydrogen is gone again.

In 1890 Dr. E. C. Pickering, then the director of the Harvard College Observatory, discovered bright lines in the hydrogen region of this star's spectrum. Making a study of the photographic records filed at Yerkes Observatory, Dr. Struve has discovered that these lines grew fainter and fainter, until they disappeared completely in 1904. They reappeared in 1911, became brighter until 1919, and have remained steady since that time. Now Dr. Struve expects them to weaken and disappear once more. But he has no explanation to hazard for such erratic behavior on the part of a distant sun.—*Science Service*

SUMMARY OF RECORDS OF STUDENTS' WORK IN CHEMISTRY IN GREELEY HIGH SCHOOL, 1924–25

FRANK S. HANNEN,* GREELEY HIGH SCHOOL, GREELEY, COLO.

The points recorded in this summary were obtained by recording the points made by each student in daily recitation, then counting these points for each student for the year. In our complete records we have the number of points made by each student for each topic studied, and also for each term.

What a "Point" Stands For

A "point" means credit for the correct statement of a law,

or for the statement of one fact in descriptive chemistry,

or for the complete understanding and statement of one step in the solution of a problem, *e. g.*, the equivalent of a metal,

or for the statement of a definition,

or for the writing or completing of an equation,

or for the writing of a formula for a compound.

We discuss each topic very fully and broadly during our study of it in class, yet when we begin the topic and when we close our discussion of it, I tell the students exactly what I think they ought to learn in order that they may *know* what the chemists *know* about that particular topic. I write it in very definite statements on the blackboard so they can see it plainly, and I tell them that that is the thing I would have them learn very exactly and just as perfectly as they can. At the next recitation, or when time has been given them to know the subject and to have learned it thoroughly, they are asked to recite on the topic, either orally or in writing, and their answers are checked according to the statements that I have given them and asked them to study carefully.

Figure 1 is a copy of the record for one section of the class, for the study of aluminum. This is the way we aim to record every topic studied during the year. Of course, we do not attain perfectly to the standard, but where we fail to do so, we know that that particular part of the work has not been covered perfectly, and the students are not held responsible for what they were not taught thoroughly. This will illustrate our records for the study of the elements.

Explanation of Records on Aluminum

Each check mark stands for an item learned. Under Purification of Bauxite, and also under Chemical Conduct, two points in one column, for one student, means that the student wrote the equation of reaction, as well as a statement of the fact. Under Uses, each check mark stands for an item learned, as a common use of the metal. The uses named at the

* Assisted by Harold Hay, Richard Lofgren, Ray Kiley, and (Hugh Neill, 1st 1/2 year).

top are considered as the minimum which a student of chemistry should know, or at any rate, an approximation towards minimum.

Where a student's record shows blank under a division of the subject, he was required to learn that topic later, in order to receive credit for the work. The reason that there is no record under Historical Notes and Occurrence is that the close of the year was approaching and the work was crowding us. Therefore, as our discussion of the subject brought these facts before our attention so that practically every one knew them perfectly, and since the recording of these items would, under the circumstances, have scarcely changed the relative points for the students, we passed them by without the regular formal recitation and recording.

Our handling of such a subject as aluminum is about as follows: Sometimes we read the text-book carefully and deliberately, questioning and talking over the various points as we go. Then we write an outline on the board as we develop it from the text, connecting the facts learned in the laboratory closely with oral and written discussion. After this, we give the students time to "learn" the subject, each in his own way (of course, with suggestions and encouragement from the teacher), and then we have them recite on the subject. The compounds and alloys of aluminum are also studied. We do not limit the students as to the scope of their discussions, although the rule is followed at all times to keep bringing the discussion back to the particular topic under consideration, and always to finish with as logical a treatment of the subject as possible.

Sometimes we introduce the subject and discuss it with the students without a text-book before us, and then let the student read the books, both text and reference, at his pleasure. Our aim, as to the text-book, is to enable the student to learn to read it and study it, to understand it and enjoy it as a source of information. Our larger aim is to make the text-book study and the laboratory work dovetail so as to enable the student's knowledge of the subject to develop along a regular line of advance.

The illustration will make it clear how the number of "possible points" noted on the "Summary" is arrived at. It will be noted that while Burbridge has a total of 43 points, she has only 5 points under Purification of Bauxite where others have 6 points. Under Chemical Conduct, Burbridge has 9 points, while Young has 10. Since no one has more points on other divisions than has Burbridge, we would consider 45 the number of points possible for any one to have learned in this subject.

Points in a Problem

The following are the divisions used by us in the problem involved in determining the equivalent of a metal:

1. Determine weight of Mg used.
2. Measure volume of H liberated from HCl.

ALUMINUM

	Hist. and Occurrence				Purification of Bauxite				Preparation by Electrolysis							Properties Physical					Chemical		
	Hall—1886	Cryolite	Bauxite	Clay	Treat with $NaCO_3$	Treat with NH_4Cl	Heat $Al(OH)_3$ dry		Iron box lined with C-cathode	Carbon anodes	Cryolite melt	Bauxite dissolved	Al-metal	O-CO	Tapped off	Color	Dens. 2.65	Hardness	Melting point	Good conductor	Tensile strength	Atomic weight	Valence
Bedinger					√	√	√	√		√	√	√	√	√	√	√			√	√			
Bowman					√	√	√	√		√	√	√	√	√	√								
Boyd					√	√	√	√	5							√	√	√	√				
Bryan, V.					√		√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√
Burbridge					√	√	√	√	5	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Carrel					√		√	√	4	√	√	√	√	√	√	√	√	√	√	√	√		√
Draper					√			√		√	√	√	√	√	√	√	√	√	√	√	√		
Evans, M.					√		√			√	√	√	√	√		√	√	√	√				
Ferguson, L.					√	√	√	√	6	√	√	√	√	√	√	√	√	√	√	√	√		
Gaines					√	√	√	√		√	√	√	√	√	√	√	√	√	√				√
Hannen					√	√	√	√	6	√	√	√	√	√	√	√	√	√	√	√	√		
Hill					√		√									√	√	√	√				
Johnson, G.					√	√	√	√	6	√	√	√	√	√			√	√	√	√	√		
Keefer					√																		
Lancaster					√	√	√	√	6	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Leggett										√	√	√	√	√	√		√	√	√				
Looney																√							
McMillan																	√	√	√	√			
Nelson					√	√	√	√	5	√	√	√	√	√	√	√	√	√	√	√			
Northway					√		√	√	5	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Poole										√	√	√	√	√		√	√	√	√	√	√	√	√
Sandstead					√	√	√	√	5	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Strahauer					√	√		√		√	√	√	√	√	√								
Thompson, H.					√	√	√									√	√	√	√	√			
Thompson, J.																							
Waterhouse					√		√	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√
Wolfe									√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Young					√	√	√	√	6	√	√	√	√	√	√	√	√	√	√	√	√	√	√

3. Read barometer.
4. Find temperature of the water (of the gas).
5. Allow for difference between water levels reduced to mm. mercury.
6. Allow for aqueous vapor tension.
7. Correct volume of gas according to Boyle's Law.
8. Correct volume of gas according to Charles' Law.
9. Compute weight of corrected volume of H.
10. Write equation of reaction.
11. Calculate weight of Mg required to liberate 1 gram H.

When the student has explained fully each step of this process to me or to an assistant, he receives credit for eleven points. Whether he completes the whole process or not in one seance, he gets credit for as many points as he explains fully, as far as he goes from the beginning without skipping any step.

Explanation of Summary of Record

In the summary of points learned by students for the year, as shown in Table I, the first column has the names of the students in each section

ALUMINUM *(Concluded)*

	Chem. Cond.							Uses									
	With HCl	With HNO_3	With H_2SO_4	With NaOH	With air and O	With water		Mfg. of steel	Mfg. of autos	Utensils	Power lines	Reduc. Mn-Cr	Paint	Thermit	Alloys		Total
Bedinger	√ √	√	√				4	√	√	√	√		√		√		26
Bowman																	10
Boyd	√ √	√ √	√ √	√ √			8	√	√	√	√	√	√				23
Bryan, V.	√	√	√	√	√			√ √	√	√	√	√	√	√	√	9	30
Burbridge	√ √	√ √	√ √	√ √	√		9	√ √	√ √	√ √	√ √	√ √	√	√	√	13	43
Carrel	√	√	√	√				√	√	√	√	√	√	√	√		31
Draper								√ √	√ √	√	√	√	√	√	√	10	24
Evans, M.								√ √	√ √	√	√	√	√	√	√	10	23
Ferguson, L.	√ √	√ √	√ √	√ √	√		9	√ √	√ √	√	√	√	√	√	√	10	39
Gaines	√	√	√	√	√			√ √	√ √	√	√	√	√	√	√	9	33
Hannen	√ √	√						√ √	√ √	√ √	√	√	√	√	√	11	33
Hill								√ √	√	√	√	√	√	√	√	9	17
Johnson, G.								√ √	√ √	√ √	√ √	√	√	√	√	12	23
Keefer								√	√	√	√	√					6
Lancaster	√	√	√	√				√	√	√	√	√		√			31
Leggett	√	√	√					√	√	√	√		√		√		19
Looney																	
McMillan	√	√	√					√	√	√	√		√				13
Nelson	√ √	√ √	√ √				6	√ √	√ √	√ √	√ √	√ √	√	√	√	13	37
Northway	√	√	√														21
Poole	√ √	√	√	√	√	√	7	√ √	√ √	√ √	√ √	√	√	√	√	12	33
Sandstead	√ √	√ √	√ √	√ √	√ √		8	√ √	√ √	√	√	√	√	√	√	10	37
Strahauer																	10
Thompson, H.	√ √	√ √	√ √				6	√ √	√ √	√	√	√	√	√	√	10	24
Thompson, J.								√	√	√	√		√	√	√		7
Waterhouse	√ √	√ √	√ √	√ √	√ √	√	9	√	√	√	√	√	√	√	√		37
Wolfe	√	√	√	√				√	√	√	√	√	√	√	√		24
Young	√ √	√ √	√ √	√ √	√ √	√ √	10	√ √	√	√	√	√	√	√	√	9	40

of the chemistry class arranged alphabetically. In the second column, senior and junior students are arranged separately in the order of points learned. In the third column, seniors and juniors together are arranged according to points. "1st hour" means the first hour in the morning, 8 to 9 oclock, "2nd hour" 9 to 10, and so on.

Note—1st hour. Robert Boyd conducted the work of a farm during the whole year and came to school when he could. Lee Keefer worked in a dairy. Percy Bowman quit school early for work. The attention of these boys to business was 100%. Paul Draper came into class just before the beginning of the last term.

3rd hour. Olivia Fry entered class just before the last term began. Donald Elliott, Everton Moss, and Ben Peyton had the first half of their year's chemistry in a previous year.

The arrangement of names in three columns on a page is for the convenience of the teacher, or student, or other interested person in finding

the standing of the students individually as compared with the total points covered in the year's work.

The variation of "possible points" in the various sections is due largely to the difference in time devoted to chemistry in the various hours of the day. The third hour was cut short frequently by general assembly programs.

A Specific Question and a Specific Case

"How does Nelson's record of 446 compare with Hall's record of 293?"

Answer: Nelson was in the section of the chemistry class that recited during the first hour in the morning. Hall's section recited the third hour in the forenoon. I, as teacher, know that Nelson and Hall were about equal in ability, but also that the general assembly period of the school came each day just before the third recitation hour, and a comparison of Nelson's record with that of Hall shows fairly accurately how much the general assembly period interfered with the following class-hour work by cutting it short on a good many days.

With this variation in opportunity, there is no way to compare the record of Hall with that of Nelson, except to go back to the records of the individual topics upon which they both recited. Even then, Nelson would have some advantage because of the slighting of some topics in Hall's hour.

The comparison that this system makes between students is between those in the same class—in the same section of the class. There the comparison is exact, so far as figures can show it. But we must be very careful to remember that there are many things in education that figures cannot show. (Furthermore, it is not the primary purpose of this system to make comparisons.)

Of course, if the teacher wishes to see in a rough way how much difference in results the difference in conditions has produced, then it may be all right to "give an examination" for the purpose of finding this out; but the teacher should remember that in such a case he is not comparing students, and he should not deceive himself as to the thing he pretends to try to do and the thing he is actually doing.

"Which is better—Nelson or Hall? And how can the reader tell?"

The reader cannot tell—until he has all the facts that the teacher has. Strictly speaking, when it comes down to fine distinctions, no one but the teacher can ever have all these facts. This is where the teacher's knowledge concerning a student stands out superior. However, if we take it for granted that the first-hour section (Nelson's) and the third-hour section (Hall's) are, on the average, equal in ability, then the comparative positions of these two students in the lists according to points made by each of them in their respective sections, is a fairly good standard of comparison.

To show how the two sections compared, on the average, as to ability, would take us outside of the purpose of this report. The primary purpose of this system is to record what each student learns—and *not to compare students*.

TABLE I

SUMMARY OF POINTS LEARNED BY STUDENTS IN DAILY WORK FOR THE YEAR 1924–25

1st hour		Seniors			Seniors and Juniors		
Boyd, Robert	120	Nelson	1	446	Nelson	1	446
Bedinger, Melbourne	145	Poole	2	322	Ferguson, L.	2	416
Bowman, Percy	182	Sandstead	3	310	Young	3	380
Bryan, Vena	227	Leggett	4	240	Burbridge	4	377
Burbridge, Mildred	377	McMillan	5	153	Hannen	5	364
Carrel, Justus	351				Johnson, G.	5	364
Draper, Paul		Juniors			Carrel, J.	6	351
Evans, Mazelle	312				Waterhouse	7	328
Ferguson, Lillian	416	Ferguson	1	416	Gaines	8	323
Gaines, Alice	323	Young	2	380	Poole	9	322
Hannen, Francis	364	Burbridge	3	377	Thompson, H.	10	312
Hill, Inez	254	Hannen	4	364	Evans, M.	10	312
		Johnson	4	364			
Johnson, Gladys	364	Carrel	5	351	Sandstead	11	310
Keefer, Lee	155	Waterhouse	6	328	Hill	12	254
Leggett, Richard	240	Gaines	7	323	Wolfe	13	250
Looney, Evelyn	163	Thompson, H.	8	312	Leggett	14	240
Lancaster, Frank	203	Evans, M.	8	312	Bryan, O.	15	227
McMillan, Warren	153				Northway	16	221
		Hill	9	254	Thompson, J.	17	211
Nelson, Ethel	446	Wolfe	10	250	Lancaster	18	203
Northway, Otho	221	Bryan, V.	11	227			
Poole, Helen	322	Northway	12	221	Bowman	19	182
Sandstead, Audrey	310	Thompson, J.	13	211	Looney	20	163
Strahauer, Louise	150	Lancaster	14	203	Keefer	21	155
Thompson, Helen	312				Strahauer	22	150
		Bowman	15	182	Bedinger	23	145
Thompson, Jeanne	211	Looney	16	163	Boyd	24	120
Waterhouse, Josephine	328	Keefer	17	155	Draper		
Wolfe, Frank	250	Strahauer	18	150			
Young, Opal	380	Bedinger	19	145	Possible points		469
		Boyd	20	120			
		Draper					

3rd hour		Seniors			Seniors and Juniors		
Agan, Nell	243	Hall	1	293	Hall	1	293
Anderson, Nina	273	Anderson	2	273	Anderson	2	273
Boxwell, Paul	209	Agan	3	243	Hipps	3	268
Bryan, Oren	213	Buzard	4	218	Johnson, T.	4	259
Buzard, Maurice	218	Boxwell	5	209	Ennes	5	246
Dauth, Leslie	139	Forester	6	180			
		Knespel	7	139	Agan	6	243
Elliott, Donald					Hunter	7	238

3rd hour		Seniors			Seniors and Juniors		
Ennes, Grace	246				Buzard	8	218
Forester, Roy	180				Bryan	9	213
Fox, Beulah	196	Juniors			Boxwell	10	209
Fry, Olivia							
Hall, Virginia	293	Hipps	1	268	Fox	11	196
Hanna, Marshall	109	Johnson	2	259	Houtchens	12	192
Hansen, Sam	237	Ennes	3	246	Johnson, H.	13	190
Hipps, Ethel	268	Hunter	4	238	Forester	14	180
Houtchens, Kathryn	192	Bryan, O.	5	213	Potts	14	180
					Jacobson	15	152
Hunter, Mary	238	Fox	6	196	Norcross	16	146
Jacobson, Mildred	152	Houtchens	7	192	Neuswanger	17	143
Johnson, Hilma	190	Johnson, H.	8	190	Dauth	18	139
Johnson, Tom	259	Potts	9	180	Knespel	18	139
Kelly, Edward		Jacobson	10	152	Walter	19	120
Knapp, Stanley		Norcross	11	146	Hanna	20	109
		Neuswanger	12	143			
Knespel, Emil		Dauth	13	139			
Moss, Everton		Walter	14	120			
Neuswanger, Frank	143	Hanna	15	109	Possible points		331
Norcross, Edna	146						
Peyton, Ben							
Potts, Virgil	180						
Walter, Max	120						

Inestimable Value of Assistants in Chemistry

Much of the credit for the large amount of work involved in completing these records for the first time, belongs to the students named as assistants. I had tried for three years to obtain such a record as this for the entire year's work, but had found it impossible to work it out alone.

These students not only did clerical work in recording credits, they also had charge of the store-rooms and the distribution of materials and equipment, they gave individual instruction to first-year students, they sometimes instructed the classes and presented demonstrations, watched the progress of the students, and helped generally in the conduct of the work.

While much work is required in getting such a history as this of each student's achievement, we believe it is the most satisfactory and the most efficient method of analyzing the qualities of the student's mental application. We believe that it is the only just way of placing a valuation upon the student's achievements, and that it is productive of the best results in his education.

A Fascinating Field of Research

We have found that watching the student's mental action, in order to discern and record each separate point made by him in his learning process, is a fascinating piece of work.

We have found this study to be a rich field of research. It has shown us

the character, the mental habits, the degree of perseverance and concentration of which the student is capable, and the interest and initiative of the individual student, more clearly and definitely than any other study.

Analyzing the Course of Study in the Light of the Students' Needs and Capacities

Through this study, and through the records which we have made, we have been enabled to analyze the subject-matter of our course of study, in the light of the needs and capacities of our students, more thoroughly than we had ever analyzed it before. By having before us a page with an exact record of the specific points in a lesson learned by each student, and of the specific points missed by each one (who missed any), we know exactly where we lost the one who needs help. In order to help these promptly, specifically, and effectively, we are compelled to have each step of the work constantly and clearly at the tips of our fingers. This, coupled with the necessity of keeping each student's work connected in a definite series of steps in his mind, constitutes, for us, the basis of a most thorough analysis of the course of study.

Watching to avoid repetition of our outstanding mistakes—mistakes which consist in missing the understanding of some of our students with our explanations and presentations of the subject—compels us naturally to use greater care each time in approaching and presenting the subject. This requires us constantly to make more certain our analysis of the subject. Each time we ask our students to explain or recite, the record made stands out very plainly in comparison with the previous record, showing the success or failure of the teacher in improving his work, even more definitely than it shows the ability of the student.

Moreover, each year's record serves as a guide for the next year's teaching. With the weak points of the work showing plainly in the record for each lesson, and with the record of the weak students before us, for the year past—there is a natural force impelling us to strengthen these weak places next year, and to avoid as far as possible the muddling of weak students at certain hard places. Also, assistants see definitely some of the teacher's problems, and some of the essentials which underlie the processes of effective teaching.

We frequently find that we have long strides to make in adapting our material and our thoughts and expressions to the immaturity of our students in science. We believe that this is a phase of intellectual training which today is being pretty generally overlooked. Personally, I find that the counsel of second-year science students is, in the long run, good. The boys who were appointed by the Principal to act as assistants in chemistry were faithful to their responsibilities in helping the first-year students, and they had a splendid attitude toward the work in general.

Freedom from Administrative Interference

In publishing this report of records made in the chemistry department of Greeley High School for the year 1924–25, I must not omit the mention of one very important and helpful circumstance—a factor, in the absence of which the present completeness of the work would have been impossible. This is the fact that Mr. George E. Brown, superintendent of the Greeley school system, aside from his requiring me to make the work in chemistry acceptable to the Northern Conference of Colleges, left me entirely free to work out the chemistry course in Greeley High School in my own way.

Also, Mr. Paul S. Gillespie, principal of the high school, left me totally unmolested in my work. And the further fact that Mr. F. A. Riedel, head of the science department of our school, never at any time during the whole year intruded any supervisor's notions into our work, never interfered in any way with our perfect freedom to cope with the circumstances which presented themselves in our particular chemistry room.

To these men I am truly grateful. Mr. Brown is very firm in his superintendency, and exceedingly strict in the administration of the duties of his office. Mr. Gillespie has been a teacher of chemistry, and, as principal, is a thorough disciplinarian. Mr. Riedel is as keen and thoroughgoing a critic as I have ever met. Yet no teacher ever had greater freedom to analyze and apply and develop his own system of instruction and record-keeping than these men gave to me during the last year.

The Point System of Teaching and Making Records Presents the Following Points of Superiority

Completeness of the records of the students' work.

Recognition of the value of assistants—in laboratory and in class work.

Makes definite the subject-matter to be learned.

Records each fact and principle which the student has learned.

Makes "grades" and examinations unnecessary, and shows them not to be an essentially integral part of the educative process; to the teacher who will use it, it will show that "grades" are diametrically opposed to true education.

Measures exactly the learning capacity, the achievement, and the progress of the student.

Benefits Secured to the Student by This System:

Simplifies the learning process.

Places before the student exactly what he is to learn in the subject, and when he has done the work, rewards him with the knowledge that he has learned a very definite thing.

Shows with perfect exactness what each student has learned in any given time.

Shows the student exactly where he stands.

With reference to the subject-matter covered in comparison with others in his class.

Places the student on his own merit.

Stimulates interest among students for the subject.

Gives definite recognition to outside influences which hinder or promote the student's progress.

Benefits Secured to the Teacher by This System:

It is flexible; it can be adjusted to each teacher's methods.

It saves energy otherwise wasted in establishing "grades," and makes it available for more productive teaching—and for living while teaching.

Eliminates guesswork on the part of the teacher as to what the student has actually learned.

Provides an exact basis on which to classify students in a given subject.

Shows the teacher exactly what he has covered in any given time.

Places the Art of Teaching More Nearly on the Basis of Exact Science:

Establishes exact basis for course of study.

Makes learning as definite as farm work or art or music, and as exact as athletics or news writing.

Establishes Supremacy of the Desire for Knowledge;

Fixes in the student's mind as a supreme thought the learning of the subject as a means of developing intellectual skill—rather than that of "getting by," or even that of getting a "high grade."

Leaves in the student's mind and heart the desire to obtain more knowledge.

Makes possible a perfect correlation of high-school and college chemistry, as advocated by the Educational Division of the American Chemical Society.

Shows that young people are generally willing to do, with the ability they possess, whatever reasonable thing is asked of them—and to do it with vim and enthusiasm.

Another Question and an Answer

"Just how does the plan used here differ from calling a whole year's work correctly done 100 per cent and rating separate items as so many per cent each?"

In the mental act—the intellectual process—of learning a fact or a law, 100 per cent is an entirely extraneous matter. It has absolutely nothing to do with learning—except to interfere with it, as will be shown in this answer. The plan used here focuses the attention of both student and teacher upon the fact or law to be learned, and from the time the fact or law has been introduced, to the time when it has become a part of the

student's working knowledge, it is the sole object of attention. In grading by means of per cent, the student is constantly tempted to think of the minimum per cent as well as the maximum—100 per cent. In this plan, there is nothing to call his attention away from the real business in hand.

When the grade shifts from the actual work to the scale of per cent, the student never knows how many factors will enter to modify or determine his grade. In this plan, the student knows perfectly that when he has learned the given fact or law or explanation so well that he can tell it to the teacher and to other students, he has accomplished just so many steps in his learning process. His record consists of his total points, and not of a *grade*. Since, in order to record a point, he must first learn a step in his work, he knows that there can be no complex or mysterious discrepancy in the process which is made up of seeing, learning, and recording, and he works with the same kind of satisfaction that accompanies the systematic doing of any other allotted work.

In the per cent system of grading, the student knows that he must shoot somewhere between the minimum and the maximum—no matter how conscientious he may be, he is aiming into the unknown future with the feeling, born both of intuition and of experience, that the mark is vague and that there is a constant strain on his aiming eye. In our system, his whole energy is concentrated on the one fact or problem or process which it is his business to learn now. There is no uncertainty on the score of "grades," no chance for a slip between the work done and the record made, to distract his mind from his present business.

From the nature of the thing, per cent grades cannot well be distributed, or awarded (or whatever the proper technical term is), until a considerable mass of material has been covered. Then an examination "given" for the purpose of determining the per cent to be awarded becomes largely a memory test. It could more accurately be called a stunt.

In our system, the record is an integral part of the process of learning. Even if it were never spread on paper records, it is recorded in the mind of the learner along with the idea that works its way into his brain cells as a part and a result of the learning process. His interest and his attention are centered on the thing to be learned, and not on a foreign object called a "grade." In other words, knowledge is the reward of effort in study. The student sees this with his own eyes; he feels it in his own mind. He is not impelled by a false system of grades to sneer at the benefits of intellectual effort.

The traditional system of grades based on per cent is inexact, inaccurate, unscientific, and unsound—therefore, it is false in its pretensions, and unjust to the student. It is the great inducement to "cramming." In the eyes of the student, it tends to discredit the teacher, the school, and the

subject of study, and leaves the student ignorant of the cause. The system of credits and records based on points actually learned is exact and scientific in its application. It removes the ground and the excuses for cramming. In the process of education, the object of the student and that of the teacher are primarily and vitally the same, and because this system leaves this relation of friendly helpfulness unmolested, it allows the student to see that his interest and the teacher's interest are identical, it tends to engender a feeling of sound, mutual respect, and therefore, promotes on the part of the student the respectful attitude of the citizen toward subjects of study and toward school, which is one chief object of all good teaching.

The Student the Center of All Educational Work

This system looks upon the student as the center around which all educational activity should circulate. Its primary purpose is, in a narrow sense, to record what each student learns—and *not to compare students*. Such being the case, we will take occasion to say here that it does not make very much difference how much or how little a "point" covers, just so the student knows exactly what he is to learn each time that he applies his attention to a subject for the purpose of learning. For example: Suppose the thing to be learned just now is the formula for soap. When the student has actually learned this formula, a point goes on his record. Then suppose next time the job is to learn to write the equation of reaction in the formation of soap. When the student has learned this, another point goes on his record. If he is next asked to learn the formulae for five different salts, and he learns them, five points are added to his record; if he learns only three of the five, then his record receives only three points.

In a broader sense this system serves to concentrate attention and effort, save labor, eliminate waste of energy caused by the scattering of attention, and thus to increase the efficiency and productiveness of the teaching-learning process. Of the several principles of teaching and learning involved herein, we shall mention three:

All students who work together are placed on the same footing, so far as the teacher can, at any given point in the progress of a group of students, place them on an equal footing.

The idea or fact or lesson to be learned must be as nearly as possible an item—an idea—an entity—a psychological unit—complete in itself. If it forms a part of a series or a process, the connections must be understood and learned later.

To learn a few things well each day is better than to half-learn many things.

LIQUID AMMONIA AS A SOLVENT*

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The chemistry with which we are ordinarily acquainted is almost exclusively the chemistry of aqueous solutions. We speak of a substance as being "soluble" or "insoluble" and in so saying we refer to water as the solvent. If the substance is soluble we treat it with some other soluble substance obtaining perhaps a precipitate. It is these reactions which go to make up a large part of our ordinary chemistry. For example, an aqueous solution of sodium iodide is added to a solution of silver nitrate and we obtain the yellow precipitate of silver iodide. And so accordingly silver iodide is classed as an insoluble substance and we carry out almost no further reactions with it, certainly no metathetic reactions. But in liquid ammonia silver iodide is one of our soluble salts and is dissociated into its constituent ions. If this solution is now treated with a solution of barium nitrate we obtain a precipitate of barium iodide. By such metathetic reactions we can obtain, with ammonia as a solvent, such substances as aluminium sulfide, chromium sulfide, and many others unobtainable by use of aqueous solution.

In water we have no such thing as a solution of a pure metal. Any solvent action which water may have on a metal is a case of reaction and not of simple solution. We all know what happens when we put sodium in water. But in liquid ammonia we can obtain solutions of such metals as sodium, potassium, barium, calcium, and the like. These are true solutions and not cases of reactions, for on evaporation of the ammonia the metal is recovered in its original state. The alkali metals are very soluble, sodium dissolving to the extent of about 168 grams in a liter of ammonia while potassium dissolves to the extent of about 320 grams per liter. The alkaline earth metals are not soluble to such a considerable extent but they are, however, appreciably soluble. Now when the metal is dissolved it ionizes into the positive metallic ion and the negative electron. For example:

$$Na \longrightarrow Na^+ + e^-.$$

Sodium ion is of course colorless, the blue color of the solution being due to the negative electron. This has been proven by electrolysis of the solution in which the positive sodium ion goes to the cathode and the negative electron to the anode. Now solutions of these metals give us valuable reagents. They are, of course, excellent reducing agents since the electron is so readily available, and these solutions are now used extensively for reduction reactions in organic chemistry. Further, these metals will replace other more electronegative metals from solution, as for example:

* Paper read before the New England Association of Chemistry Teachers at Brown University, March 14, 1925.

$$Na + AgI \longrightarrow NaI + Ag$$

whereby the silver is precipitated out in a finely divided form.

Now the question naturally arises, do we have acids and bases in liquid ammonia solution? In the water system, water ionizes into positive hydrogen and negative hydroxyl ions. Substances giving hydrogen ions we call acids and those giving hydroxyl ions we call bases. And so we say that acids are substances which, when in solution, yield positive ions in common with the solvent, and bases are substances which yield negative ions in common with the solvent. Now these ions are more or less solvated and the complex formed may be more or less stable depending on the case. Ammonia will ionize, only slightly to be sure, according to the equation:

$$HNH_2 \longrightarrow H^+ + NH_2^-.$$

Hence we see that acids in liquid ammonia are substances yielding NH_4^+ ions (the solvated or ammonated hydrogen ion) and bases are substances yielding NH_2^- ions. That is, NH_4Cl, NH_4NO_3, or any ammonium salt is an acid in liquid ammonia and is called an ammono acid. KNH_2, $NaNH_2$, or any amide is then an ammono base. The following will illustrate the action of ammonium salts as acids: One of the typical reactions of an acid in water solution is its action on metals forming the salt of the metal and liberating hydrogen. In ammonia solution ammonium salts will attack metals in the same manner. NH_4Cl added to our solution of sodium will form sodium chloride and liberate hydrogen according to the equation:

$$2NH_4Cl + 2Na \longrightarrow 2NaCl + H_2 + 2NH_3.$$

Magnesium, zinc, and the other more electropositive metals are acted on similarly, only of course not as rapidly, since these, unlike sodium, are insoluble in liquid ammonia.

By the use of liquid ammonia as a solvent we have come to recognize the presence of metals in the electronegative condition. For example, we have the salt Na_4Pb_9 which when dissolved in ammonia ionizes according to the equation:

$$Na_4Pb_9 \longrightarrow 4Na^+ + Pb_9^{----},$$

where the Pb_9 ion is a complex negative ion analogous to our complex sulfide S_x ion. Now if a solution of this salt is treated with a solution of a lead salt as $PbCl_2$ where we have lead as a positive ion Pb^{++} we have the reaction:

$$Na_4Pb_9 + 2PbCl_2 \longrightarrow 4NaCl + Pb_2Pb_9$$

and ordinary metallic lead is precipitated out. Here a positive lead ion has combined with a negative lead ion, or at least they have neutralized each other, forming free metallic lead. The reason for our not having

recognized these salts of metals in the negative conditions is that they do not exist in aqueous solutions. The following reactions will illustrate this. In water solution we have metallic tin reacting with potassium hydroxide according to the equation:

$$Sn + 2KOH \longrightarrow Sn(OK)_2 + H_2.$$

Now just what is the mechanism of this reaction? Certainly potassium hydroxide is not acting here as an acid. By looking into the analogous reaction in liquid ammonia we can obtain an intelligent explanation of the above reaction. In liquid ammonia we have stated that KNH_2 is a base. If we treat tin with our base we have the following reaction:

$$3Sn + 4KNH_2 \longrightarrow K_4Sn + 2Sn(NH_2)_2.$$

The amphoteric base $Sn(NH_2)_2$ will further react with KNH_2 to form an ammono salt.

Now let us consider our reaction in water in the light of this reaction. The first reaction of tin with the base will be:

$$3Sn + 4KOH \longrightarrow K_4Sn + 2Sn(OH)_2.$$

The amphoteric base $Sn(OH)_2$ will react with KOH to form a salt:

$$Sn(OH)_2 + 2KOH \longrightarrow Sn(OK)_4 + 2H_2O.$$

But our K_4Sn in water is not stable. It reacts with water according to the equation:

$$K_4Sn + 4HOH \longrightarrow 4KOH + H_4Sn$$

and H_4Sn then decomposes according to the equation:

$$H_4Sn \longrightarrow Sn + 2H_2.$$

On summing up the above series of equations it is seen that the resulting equation is:

$$Sn + 2KOH \longrightarrow Sn(OK)_2 + H_2.$$

Thus we see that the chemistry of liquid ammonia solutions is in reality exceedingly extensive, and the use of ammonia as a solvent has given us a deeper insight into the chemistry of many substances and reactions than was possible before its use.

General Organic Chemistry Symposium. Further arrangements are being made for the general symposium on organic chemistry to be held at Rochester, N. Y., on December 29, 30, and 31, 1925. The program should prove most interesting and helpful. The following people will attend the meeting and have consented to present papers: R. R. Renshaw, Morris Kharasch, Harry L. Fisher, Homer B. Adkins, B. Johnson, Treat B. Johnson, W. J. Hale, E. H. Volwiler, A. W. Browne, L. E. Wise, Roger Adams, Frank C. Whitmore, R. J. Anderson, W. Lee Lewis, James F. Norris, A. J. Hill, W. L. Evans, M. T. Bogert, J. B. Conant, John Johnston, and Charles H. Herty.

A PAINLESS METHOD

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Whatever may be the literary demerits of the type of composition commonly designated as the news article, one must concede to it certain practical virtues. In its best form it achieves, with notable success, its objectives, which are: to attract and fix the attention of the observer; to arouse curiosity and interest; and to sustain that interest while recounting the facts.

Somewhat the same psychology of attack is employed in the plan here described. Those who "view with alarm" the alleged modern desire to sugar-coat the bitter pills of learning may console themselves with the assurance that such procedure is seldom enough possible. Those who consider palatability an aid to the assimilation of mental pabulum will find helpful suggestions in Miss Fillinger's article.

Few of us reach the stage where we do not gladly add to our store of knowledge with the least possible expenditure of energy. We are therefore not surprised at the eagerness with which the undergraduate, and especially the college freshman, welcomes any "painless" method of getting information. Often, too, information gained somewhat unconsciously or subconsciously makes the most lasting impression. However, care must be exercised in not over-estimating the value of this point. To meet this natural desire of the student and for several more or less obvious reasons, some of which will be discussed below, the writer has used for several years a popular science bulletin board to supplement the lecture discussions of current events in chemistry.

The primary objects in view in the use of this bulletin board may be stated as follows:

1. To secure and hold the interest of the student.
2. To keep constantly before the student the close relationship between chemistry and related sciences.
3. To give the student a personal attitude toward the course and a sense of responsibility for its success.
4. To help the student voluntarily form the habit of reading scientific papers and of noting scientific articles in non-scientific papers.

In the experience of the writer each of the above objectives has met with some success and there have also been some interesting "by-products" of the project. Hoping that some helpful suggestions may be made, a brief discussion of the above points and of the way in which the bulletin board is conducted is herewith given.

In teaching students many of whom, because of our present elective system in high schools, have little knowledge of any science or the value of scientific training, the writer has found that there is little time for more than the minimum amount of descriptive material to hold the interest of the average student. Since the writer makes every effort to develop the student by giving him a working knowledge of the fundamental principles of chemistry and an appreciation of the science, the reader can readily understand that descriptive material must take second place. The popular science bulletin board has proved very helpful in conserving lecture time and in supplementing lecture discussions with interesting de-

scriptive material and thus in holding the interest of the student. Short, attractively written articles, together with illustrations, pictures, or drawings, are cut from current papers or typewritten copies of articles from books which may not be cut are placed on the board each week by an instructor or student. Except for current discoveries, articles as closely related to class discussions as possible are selected. It often happens that current articles coincide remarkably well with class discussions. Two or three such instances come to mind. A year or so ago during a lecture discussion of the Haber process of the synthesis of ammonia, the *Science News-Letter* contained an article discussing the demand of France upon Germany for the secret of the process. The opportune appearance of this article on the bulletin board interested the students very much; in fact, its appearance on the board seemed to interest them more than the mentioning of the article in the lecture room. Articles came out announcing the discovery of hafnium shortly after discussions of the periodic table and spectrum analysis. This confirmation of the value of the table and of spectrum analysis in chemical research was far more impressive than several fulfilled predictions of many years ago. Dozens of similar instances could be cited. Sometimes a short article on work to be discussed the following week is used—something that will give a mere suggestion and which will arouse interest or curiosity, if not sensational, is good. Occasionally an advertisement which may be in accord with principles of good psychology but which is bad chemistry has been used to arouse interest in a discussion in a following lecture or to illustrate the advertiser's play on the ignorance of the public. This has been particularly helpful in illustrating the relation of chemistry to the home and the value of some knowledge of chemistry in the home. Quotations and terse sayings of eminent scientists and others are put on the board from time to time. In fact the department tries to select, in so far as time permits, any material that will be interesting and helpful to the student but for which there is not time in the lecture room.

Doubtless the objection will be raised that not all of the students will get this information. This is true because the reading of the articles on this bulletin board is entirely voluntary, but it can truthfully be said that not all students hear all of a lecture-room discussion and that not all who hear remember what they hear. The students who do read the articles on the bulletin board because chance has given them a few minutes in front of the board or because attention has been called to an article by an instructor in the lecture room or in the laboratory will often remember the facts with more interest than they do many lecture-room discussions. It should be kept in mind, however, that it is not the purpose of the popular science board to replace lecture-room discussions; it should only supplement them with worthwhile material which, if discussed fully in the lec-

ture room, would have to be given at the expense of more important material.

In the opinion of the writer, giving the students of general chemistry an appreciation of the close relation between chemistry and other sciences is an important part of a first year course. It is also important to bring out directly and indirectly, so far as possible, the bearing of chemistry on the other subjects the student is studying. This is particularly necessary if the student is taking chemistry only as a required subject. Many times the interest and later the enthusiasm of a disinterested student have been obtained by this method. The popular science bulletin board has been very helpful in this constant effort to relate knowledge in all subjects. Therefore, not only articles strictly chemical are used but also articles relating to discoveries in any scientific field are included on the board. Of course, particular attention is given to discoveries in those fields in which chemistry has directly or indirectly had a part. Articles on the discovery of the anaesthetic property of ethylene, the nature of the aurora borealis, or photographs of the spectrum of the corona of the sun during a current eclipse, have proved of as much interest to the chemistry department as to the respective fields of science more definitely represented. If the student partially discovers for himself this close relation between sciences and the dependence of some discoveries in other fields upon a knowledge of chemistry his interest is greatly increased—and the importance of securing the interest of the student can hardly be overestimated. Once the student is interested and impressed he begins to search out this relationship in all his reading even in his history and literature courses. Valuable results of this kind have been obtained—and it might be mentioned parenthetically that the respect of the student gained by this "broad-minded" attitude toward other subjects is not without its effect in holding his interest. It has been noted with pleasure and satisfaction that information from the chemistry bulletin board has been carried by students to classes in the respective fields represented by the articles even before attention has been called to the discovery in the department represented. This has helped to give the students an interest and pride in the bulletin board and in the department which is quite worthwhile. Aside from the interest aroused by helping the student correlate information gained in all courses, the bits of information in archaeology, astronomy, biology, geology, or other science he acquires while studying chemistry may be a good part of the information he will get in some of these sciences while in college. The majority of students do not take more than the one or two required sciences. The writer believes that the teacher of the required sciences has a special responsibility to the student not majoring in science and she has found the popular science bulletin board very helpful in meeting this obligation.

A sense of pride in the bulletin board and responsibility for its success

are increased by inviting the students to make contributions to the board. The student who reads the bulletin board somewhat regularly is likely to notice scientific articles in his reading and to want to bring them to the bulletin board and the student who contributes to the board is sure to read other articles on it. This scheme serves both to stimulate a sense of responsibility and voluntary reading and to furnish interesting material which might escape the attention of the chemistry faculty. This feature should prove even more successful in high school than in college because usually a student would be allowed to cut articles from magazines in the home whereas much of the material the college student has access to is in the library and may not be removed. In spite of this fact, however, there have been, during the experiment with the popular science bulletin board, a goodly number of contributions and the attention of the chemistry faculty has been called to many articles which could not be brought to the board.

The fourth objective of the popular science bulletin board mentioned above needs no discussion at this point as it has already been covered in the discussion of the other points. It is by no means the least important of the four.

As to the source of material it may be said that in so far as time permits every authentic source available is drawn upon. The source of the article is given and the student is encouraged to weigh the article accordingly. Another "by-product" or two of this bulletin board will become obvious to the reader at this point. The following are some of the sources most regularly drawn upon at present: the journals of the American Chemical Society, especially *Industrial and Engineering Chemistry*, and news section and the JOURNAL OF CHEMICAL EDUCATION (frequently advertisements from some of these are interesting during discussions of alloys, etc.); the *Science News-Letter*, a valuable source of current articles of the proper length; bulletins published by local and state branches of the American Chemical Society; biographies; books published by the Chemical Foundation; the *Scientific American;* and *Science*. Newspaper articles are also used with discretion. Articles which appeal particularly to advanced students in the department are included as well as those that appeal most directly to the general chemistry class, in a very large department probably more than one bulletin board would be advisable. In the experience of the writer the advanced student enjoys the articles, uses the information in the class-room, and in departmental clubs, and takes a real departmental pride in the board.

It is believed that the popular science bulletin board can be made an important factor in the teaching of chemistry, but several points must be kept in mind in order to make it a success.

The articles should be very short as a rule, some of them short enough to

be read in the minute or two the student is waiting his turn at the supply store or in the two or three minutes in which "he has nothing else to do." Generally an effort is made to limit the entire contents of the board to an amount that can be read carefully in fifteen to twenty minutes.

Pictures should be used as often as possible, at least one picture should be on the board each week. Sometimes a picture and a few sentences tell a story quickly and more effectively than a long discussion would. Photographs and biographical sketches of eminent chemists prove interesting especially if used during lecture-room discussions of some of the work of these scientists. The writer often tries to precede a technical lecture discussion of some fundamental principle by the above method or by a short biographical sketch assigned as parallel reading. The use of these photographs in lanterns in the lecture room will not necessarily make it undesirable to use some of them on the board after the lecture as the interested student will be glad to study the face of the chemist conveniently at his leisure. Care should be exercised in the arrangement of articles on the board in order to attract the attention of the student and urge him to stop. The contents of the board should be changed regularly so that the students will know when to expect new material. Often, however, an especially good article is left on the board two weeks but it is usually given a new position in rearranging the contents of the board. This bulletin should be kept entirely for voluntary reading by not using it for information that the entire class is required to have. Above all, the board should be placed where the student must pass it as often as possible while in the chemistry building or in the part of the building occupied by the chemistry department.

Make it impossible for students to escape the lure of the popular science bulletin board and many of them will get a little information each week by the "painless method" and many of those who read will become interested and will remember. A casual look, if something interesting is seen, will usually lead to a closer examination.

THIRD ESSAY CONTEST CLOSES EARLIER

Teachers should note that the closing date for entries in the A. C. S. Prize Essay Contest has been advanced to February first. A small pamphlet entitled "The A. C. S. 1925–26 Prize Essay Contest" has been prepared and may be obtained from the Chemical Foundation at 85 Beaver Street, New York City. This publication contains a list of the 1924–25 prize winners, complete rules and regulations governing the new contest, and a statement of the arrangement whereby the books recommended for reference use are made available.

THE DETERMINATION OF THE FORMULA OF CARBON DIOXIDE[1]

W. L. EVANS, J. B. PETERSON, H. B. HASS, G. P. HOFF, AND J. E. DAY, OHIO STATE UNIVERSITY, COLUMBUS, OHIO

This paper gives an account of our efforts to devise suitable experiments which might easily be carried out by students in general chemistry whose task is the determination of the exact formula of a given chemical compound. In searching for a suitable compound to illustrate this fundamental principle, we encountered many difficulties which would prevent us from obtaining the quantitative composition of the substances which we would like to have used. In many cases we found that the determination of the gram molecular weight of many compounds familiar to beginners would require manipulation entirely too difficult for students of limited chemical maturity. As a result of our study and experience in this problem we chose carbon dioxide as an experimental compound. Besides lending itself to the solution of our problem it has the very great advantage of being a substance well known to the students.

Experimental Part

The quantitative composition of carbon dioxide was obtained by a synthetic method. This was accomplished in almost the same manner as water is prepared by the classical experiments of Berzelius and Dumas. An apparatus is arranged as shown in Figure 1. About a half-gram of granular activated charcoal (not powdered), placed in a porcelain boat, is heated to just below the glowing point for an hour. After the boat and its contents have been cooled in a desiccator to room temperature they are

Expt.	Ratio of O:C	Expt.	Ratio of O:C
1	2.00:1	6	2.07:1
2	1.90:1	7	1.98:1
3	2.03:1	8	2.07:1
4	2.05:1	9	1.99:1
5	1.97:1	10	200.:1

carefully weighed and then introduced into a hard glass tube which has a wire gauze shield as shown in the figure. Now connect the calcium chloride drying tube and the previously weighed U-tube containing soda lime and calcium chloride. By the cautious introduction of water through the funnel, oxygen is forced very slowly from the 1000 cc. bottle over the carefully heated charcoal. If the charcoal begins to glow, the burner may be withdrawn as the exothermic character of the change is sufficient to maintain the reaction as long as oxygen is passed over it. When sufficient oxygen has passed over the charcoal to form about one gram of carbon

[1] Read before the Division of Chemical Education of the American Chemical Society at Milwaukee, Sept. 13, 1923.

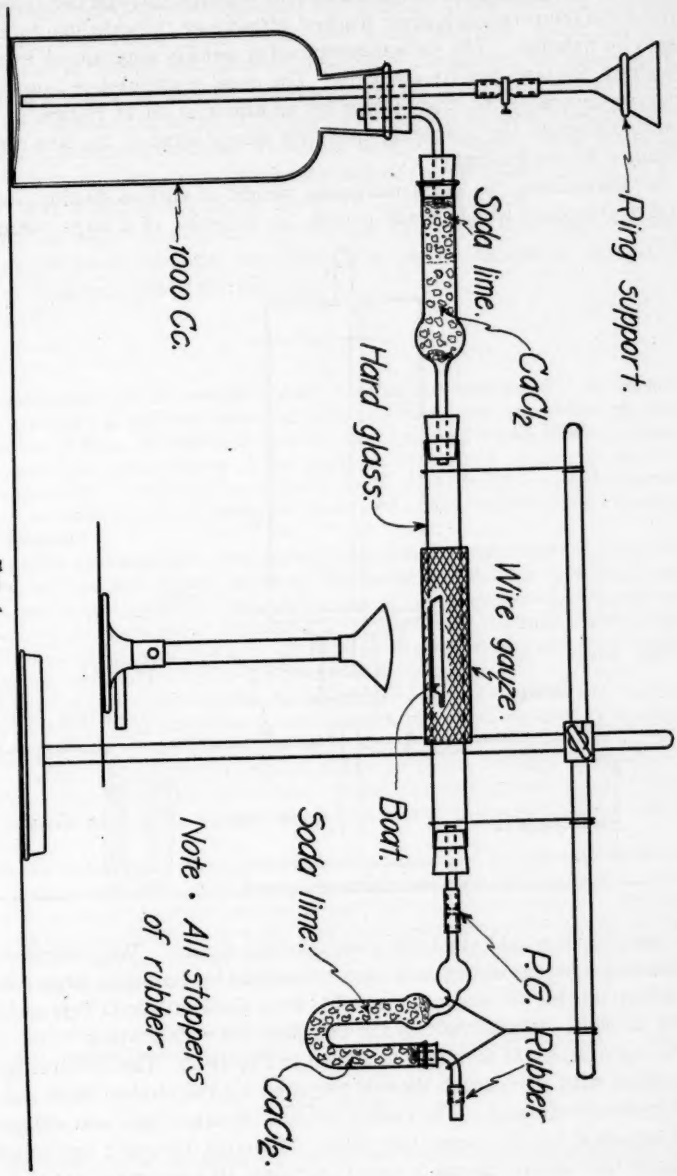
Ring support.
Soda lime.
$CaCl_2$
Hard glass.
1000 C.c.
Wire gauze.
Boat.
Soda lime.
P.G.
Rubber.
$CaCl_2$.
Note • All stoppers of rubber.

FIG. 1.

dioxide, the heating is discontinued and air is swept through the apparatus until room temperature is again reached, after which the soda lime tube may again be weighed. The carbon consumed is quickly determined by again weighing the boat and its contents. The usual manipulative precautions suggest themselves to any teacher by an examination of Figure 1. The results shown in the preceding table are among some of the best of those obtained by the students.

In determining the gram molecular weight of carbon dioxide, we felt that a procedure which would permit the weighing of a large volume of

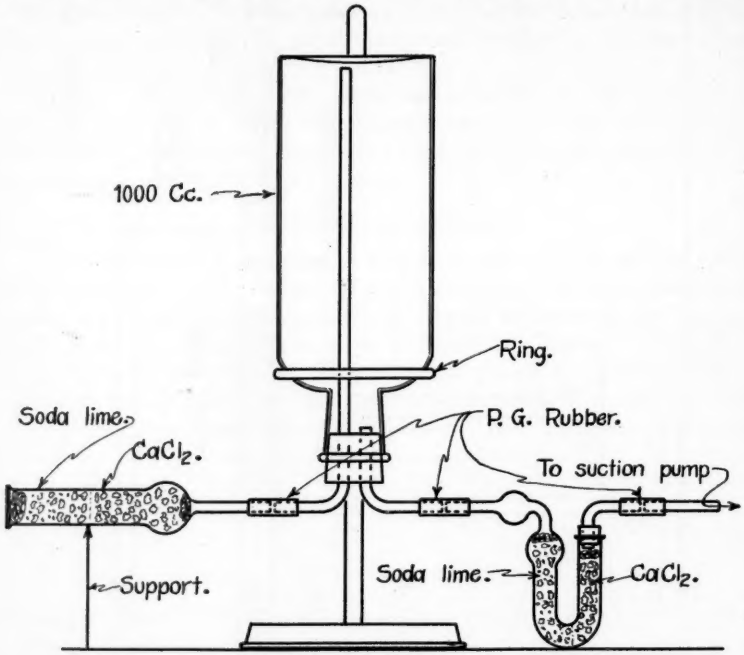

FIG. 2.

carbon dioxide would yield the most accurate results. We overcame the difficulties inherent in weighing large containers by causing a large volume of carbon dioxide to pass into a small U-tube filled with soda lime and calcium chloride. The advantages of this plan are very obvious.

An apparatus was arranged as shown in Figure 2. The 1000 cc. bottle was filled with dry carbon dioxide prepared by the student from marble and hydrochloric acid. The carbon dioxide container was now stoppered and attached to the absorption train. Through the soda lime-calcium chloride tube and by means of a suction pump, air was drawn into the pre-

viously weighed U-tube as indicated in Figure 2. This operation required about 10–15 minutes. The U-tube was again weighed. After reducing the volume of carbon dioxide used to standard conditions, the student was then in a position to calculate the gram molecular weight of the compound. As stated above, the usual laboratory precautions in manipulation must be strictly observed in order to obtain accurate results. The following figures are taken from among the best obtained by our classes: 44.06, 43.73, 43.68, 44.0, 44.42, 44.57, 43.13, 44.80, 43.32, 43.42, 43.01.

From the data obtained in both parts of this paper it is clear that the student can easily establish the formula of carbon dioxide as being CO_2 and not some multiple of this formula.

Disinfectant Acts by Invisible Rays. That sodium hypochlorite, the common disinfectant used in drinking water and swimming pools, does not sterilize by direct contact but by means of germ-destroying invisible rays which it gives off when it comes into contact with organic matter, is the conclusion drawn from experiments made by French chemists, M. Philippe Bunau-Varilla and M. Emile Techoueyre, and communicated to the Academy of Sciences by M. Jean Perrin, Professor of Physical Chemistry at the Sorbonne.

It used to be thought that the purifying power of the compound was due to chemical reaction, as it oxidized organic matter and decomposed itself. But while M. Bunau-Varilla was trying to determine the smallest amount of sodium hypochlorite necessary to sterilize a given amount of drinking water and not leave the usual chlorine taste, he found that the quantity necessary was too small to enter into any appreciable chemical reaction, and this fact suggested his ultra-violet ray theory.

A series of experiments was then devised to prove or disprove the theory. A tube of quartz, which, unlike glass, is transparent to ultra-violet rays, was filled with a dilute solution of sodium hypochlorite and placed within a larger tube of quartz. The interspace was filled with water contaminated with colon bacilli, and the combination immersed in a bath of hypochlorite solution. An identical arrangement of quartz tubes, but lacking the surrounding disinfectant was prepared and the sets were allowed to stand 2¼ hours.

In order to find out if the hypochlorite had really given off death-dealing radiations, drops of the contaminated water were taken out of both tubes and "planted" in dishes of gelatin—a sort of bacterial dinner pail—where they were allowed to grow. The solution containing the most bacteria would grow the largest number of "colonies," and vice versa. In 51 times out of 60 the contaminated water that had been surrounded for 24 hours by the hypochlorite solution grew fewer bacterial colonies than water not so exposed.

It appears from these experiments that the hypochlorite gives off ultra-violet rays which, passing through the quartz, destroy the microbes that they reach.—*Science Service*

The knowledge of nature as it is—not as we imagine it to be—constitutes true science.—*Paracelsus*

THE USE OF THE TRUE AND FALSE TEST IN CHEMISTRY TEACHING*

WM. H. SPURGIN, HYDE PARK HIGH SCHOOL, CHICAGO, ILL.

There is a decided movement among teachers of all subjects to depart from the conventional "essay" type of examination in favor of some type which calls for shorter and more specific responses on the part of the pupil. Four such types are in common use: (1) The short answer type, in which the question is capable of being answered in a single word or, at most, a brief phrase. (2) The completion test, the pupil filling in blanks with the appropriate word or phrase. (3) The best answer test in which a question is asked and four or five possible answers suggested, one of which is the correct answer. (4) The true and false test in which a statement is made and the pupil required to say whether it is true or false. The advantages claimed for these types of examinations are: (1) it is not so easy for the pupil to evade the real point at issue; (2) a larger amount of subject-matter may be covered since the time taken in setting down the answers is slight; (3) greater objectivity in grading is possible.

In order to determine how closely the scores on a true and false test would correlate with the pupil's real knowledge, fifty questions made out in the form of a short answer test were given as a final examination in chemistry to fifty-five students. As soon as each student had finished this test his paper was taken up and he was given the same test in true and false form. The average grade in the short answer test was 30.9—in the true and false test, when scored by the method in most common use, namely, subtracting the number of mistakes from the number of correct answers, was 27.0. The coefficient of correlation between the two sets of scores was 0.873.

This method of scoring the true and false test assumes that the student answers correctly the questions he is sure of, and guesses half the rest right, and the other half wrong. Analysis of the results showed that out of 151 cases where the pupil did not attempt an answer on the short answer test, 100 were "guessed" right on the true and false test. This bears out the view that a student may not possess a knowledge definite enough to formulate a correct answer himself, but be able to recognize the correct answer or detect the wrong one.

Man's work must ever end in failure,
Unless it bear the stamp of mind.
The head must plan with care and thought,
Before the hand can execute.

—SCHILLER.

* Delivered at the April meeting of the Chicago Association of Chemistry Teachers.

A CHEMISTRY INFORMATION BUREAU

Soon after the Iowa Committee on Chemical Education was appointed in the fall of 1924, the writer secured the hearty coöperation of the leading chemistry teachers of Iowa in universities, colleges, and high schools in the organization of what might be called a chemistry information bureau.

To this bureau any teacher in the state might refer any problem connected with his teaching on which he might wish help or information. It was believed that this might be taken advantage of quite generally, especially by the less experienced teachers.

The plan proposed that requests for information be sent to the writer, as chairman of the committee, enclosing therewith two stamped envelopes, one plain and the other self-addressed. The writer would then transmit the questions to the one best qualified to answer them and the reply would go direct to the one making the request.

The *raison d'etre* of this article lies in the fact that the editor-in-chief of THIS JOURNAL considered the plan a valuable one and suggested that it be made nation-wide and that it be promoted under the auspices of the JOURNAL. To this the writer cheerfully acceded and agreed to give it publicity in an initial article.

It is proposed, therefore, that there be a "Correspondence" department maintained in the JOURNAL in which questions and answers which might be of general interest will be included. All questions will be addressed to the Editor of the JOURNAL OF CHEMICAL EDUCATION, College Park, Md., from whose office they will be transmitted to those most competent to answer, as in the Iowa plan.

It is hoped that teachers will very freely take advantage of this suggestion. It is possible that some may hesitate to do so, fearing that the question might seem to indicate incompetency. It should be remembered, however, that the failure to present most efficiently a subject reacts to the detriment of the pupils who, after all, deserve the greatest consideration. It is, therefore, the duty of every teacher to take advantage of every opportunity to improve his teaching. No matter what the problem may be, whether one of equipment, of methods of presentation, of information supplemental to the text, etc., etc., the JOURNAL through those coöperating with it, will gladly try to solve it and keep it confidential if so desired.

F. E. GOODELL, Des Moines, Iowa

Chemical Digest

ABSTRACTS

The Almighty Atom. C. E. BECHHOFER ROBERTS. *World's Work*, **50**, 414–23 (1925).—A sketch of the modern ideas of the nature of the atom and the workers in that field, namely: Bohr, Einstein, Zeeman, Planck, and others. From five months' constant touch with the most brilliant workers in this field the author speaks first-hand of these men.

Rutherford's theory of a nuclear atom model, refined and coördinated with Lorenz' electronic emission theory for explaining spectrum lines, Moseley's atomic numbers for elements, and Planck's quantum theory, gives the accepted concept of atomic structure as the author of the article understands it.

Thus, "the atom is destined to be the victim of modern scientific progress. Day in and day out in a thousand laboratories all over the world it is being probed and battered and bombarded, heated to enormous temperatures in electric furnaces and even frozen to within a degree of absolute zero, —273° centigrade," in an effort to make it yield its secrets. F. B. DAINS

The Spirit of Science. EDITORIAL. *Colliers*, **27**, 22 (1925).—Mr. Putnam is quoted as stating concerning his patent on balloon tires: "I am content to let the industry and the public as a whole take the benefit of my invention. This patent is not going to be used to hold up anyone."

Commenting on this the editor says, "There speaks the spirit of science. Chemist and physician and engineer have long been giving freely to the world the fruits of their researches. Your true scientist sets far more store upon his reputation and upon his contribution to the total accumulation of knowledge than he does upon exclusive patents and a huge fortune. All honor to those pioneers who begin to bring into business the spirit of science." J. W. HOWARD

Basis of Physical Comfort in Relation to Air Temperature. E. VERNON HILL. *Am. Sch. Board Jr.*, **7**, 43–6 (1925).—The air we breathe and the air in which we live require different emphasis. Chemical composition and differences are not as important as the physical properties. The terms foul air and crowd poison are almost meaningless now. Extensive experiments have shown that for maximum comfort, the temperatures and saturations of air are as follows: 64°, 100% sat.; 65°, 90% sat.; 67°, 70% sat.; 69.5°, 50% sat.; 75°, 15% sat. We pay a great deal of attention to temperature controls, but not enough to humidity and its control. Much teaching effort is wasted on account of poor air conditions. SY

Ox Cart or Auto—Which? E. VERNON HILL. *Am. Sch. Board Jr.*, **8**, 49–55 (1925).—Some think that heat stagnation is the only cause of discomfort in badly ventilated rooms. Moisture, stillness, and warmth are also factors. Of course air should be clean and plentiful. The amount of CO_2 is an index to school odor. The minimum of fresh air should be 30 cu. ft. per minute per occupant. SY

X-Ray Crystal Analysis as an Auxiliary in Organic Chemical Research. R. ROBINSON. *Nature* **116**, 45 (1925).—A series of four keto acids were synthesized by Mrs. Robinson and sent at the suggestion of Professor W. L. Bragg to Dr. G. Shearer of the Davy Faraday Research Laboratory. Dr. Shearer was not aware of the identity of the substances which were, however, stated to belong to the series $CH_3(CH_2)_mCO(CH_2)_nCO_2H$, actually (A) was $CH_3(CH_2)_{11}CO(CH_2)_8CO_2H$; (B) was $CH_3(CH_2)_{11}CO(CH_2)_4CO_2H$; (C) was $CH_3(CH_2)_7CO(CH_2)_6CO_2H$ and (D) was $CH_3(CH_2)_8CO(CH_2)_8CO_2H$. No case so complex had been tried in the aliphatic series previously and yet from X-ray examination of a minute amount of these compounds, Dr. Shearer was able to deduce that (A), (B), (C), and (D) have chains containing 22, 18, 16, and 19 carbon atoms, respectively. Furthermore, it was possible to assign positions to the carbonyl groups in (A), (B), (C), and (D) from a consideration of the distribution of intensity among the various orders of reflection from the principal planes and it was found that the carbonyl group is 0.52, 0.67, 0.55, and 0.50, respectively, of the whole length of the molecule from the end terminating in a methyl group. The corresponding theoretical values are 0.54, 0.65, 0.50, 0.48 which means a maximum error of one carbon atom in placing the oxygen. H. K. M.

The Faraday Benzene Centenary and Kekulé. H. BORNS. *Nature*, **116**, 48 (1925).—Borns points out that the name Kekulé is not French. August Kekulé, born in Darmstadt (1829; he died in Bonn, 1896), was a descendant of Wilhelm Dionysius Kekule (or Keckhule) von Stradonitz, who came from Bohemia in the seventeenth century. The é was probably adopted to guard against the suppression of the final e. By the time of the international Kekulé celebration at Berlin 1890 he had resumed the full name A. K. von Stradonitz. H. K. M.

Two New Elements of the Manganese Group. EDITORIAL. *Nature* **116**, 54–5 (1925).—The recent discovery of the eka-manganeses by Drs. Noddack and Tacke is of interest not only as an important step towards the completion of the periodic table but also on account of the methods used in the research. Chemistry, physics, and mineralogy have all played their parts. A study of the neighboring elements suggested two possible sources; the first that of the platinum ores, the second a mineral such as columbite. The platinum ores contain the elements Cr to Cu, Ru to Ag, Os to Au, or, expressed in atomic numbers, 24 to 29, 44 to 47, and 76 to 79. Columbite contains, among many other elements, those of atomic number 39 to 42 and 71 to 74. The constitution of the earth's crust is now fairly well known, and it is possible to assign to the various elements numbers indicating the frequency of their occurrence. A study of these figures indicates that an element of odd atomic number is ten or twenty times less abundant than the succeeding even element. In this way N. and T. obtained some idea of the extent to which the chemical processes of extraction would have to be carried if measurable quantities of the new substances were to be obtained. It was a fairly straightforward matter to predict some of the chemical properties from a consideration of their neighbors in the periodic table. These were made use of in the treatment of the ores.

A substance having the expected behavior was obtained from the platinum ores but further attempts at concentration resulted in a loss of the material. Through lack of further supplies of the platinum ores the attention was turned to columbite. After the final treatment the quantity of material available was too small for direct application to the anticathode of the X-ray tube. It was therefore mixed with niobic acid and examined spectroscopically in this form.

From Moseley's laws it is possible to predict the wave lengths of the various lines with considerable accuracy. A further check is provided by an examination of the relative intensities of the lines. Three lines appeared on the plates corresponding to wave lengths 0.601, 0.672 and 0.675 Å. U., whereas the calculated value of $K\beta_1$, $K\alpha_1$, and $K\alpha_2$ lines for an element 43 are 0.600, 0.673, and 0.678 Å. U. These are the three strong lines of the K series and their relative intensities agreed with the well known ratios. In the spectral region 1.20 to 1.43 Å. U., there occurred five lines which were identified as the $L\alpha_1$, $L\alpha_2$, $L\beta_2$, and $L\beta_3$ lines of an element of atomic number 75. The numerical agreement was excellent; thus, the observed and calculated wave lengths of $L\alpha_1$ line were 1.4299 and 1.4306 Å. U. There is always a chance that the lines may be wrongly identified but due precaution against any possible misinterpretation appears to have been taken and there seems no doubt that these lines are actually due to the presence in the columbite residue of the elements 43 and 75. This research is all the more interesting because certain writers have put forward arguments suggesting that a search for the eka-manganeses must prove fruitless. The discoverers suggest that the elements be named masurium (Ma) and Rhenium (Re), after the district of Eastern Prussia and after the Rhine, respectively. H. K. M.

Preliminary Note on the Transmutation of Mercury into Gold. H. NAGAOKA. *Nature*, **116**, 95–6 (1925).—N. applies an intense electric field to mercury atoms. An induction coil of 120 cm. spark length was available. For keeping the terminal voltage between the electrodes sufficiently great with a short spark gap the discharge was conducted in paraffin oil in which a potential difference of about 15×10^4 volts/cm. can be maintained. With iron and purified mercury as electrodes the discharges appeared at first as arcs, and the spectrum was continuous; it gave rise to abundant production of gases and carbon particles from the oil; the mercury gradually turned into fine globules until the oil and mercury were mixed into a black pasty mass. Continuing the discharge for four hours, the product was examined chemically for gold by the test of Cassius' purple; the result was decidedly positive. Mr. Yasuda, an expert on gold assaying, extracted minute gold specks from the black mass obtained in the experiment. Grave doubts were, however, expressed by critics as to the purity of the mercury and also as to the possible presence of traces of gold in the chemical laboratory due to frequent treatment of the metal.

To clear away these doubts the mercury was purified by ordinary chemical means and then subjected twice to vacuum distillation, care being taken not to raise the temperature above 200°. The oil and chemical reagents were carefully examined by making blank tests. A room in the physical laboratory was allotted to the chemical experiments. Tungsten wire, free from thorium oxide, was used instead of iron.

As to the method of testing, the formation of ruby glass is delicate and in most cases is accompanied by the separation of gold particles at the center or outside boundary which can be observed with a metallographic microscope by using reflected light. The gold obtained from the mercury seems to be mostly adsorbed to carbon. Ruby glass is formed by heating small pieces of glass with the carbon. Photographs are included.

The process taking place may be looked upon as due to commotion in the nucleus by intense electric force. If we assume that Coulomb's law ceases to hold within the nuclear boundary, the positively charged protons form a compact core and the electrons within the boundary surround it. On applying an external electric field the motion of the core is opposite to that of the electrons, so that if the field be sufficiently strong it is possible that some of the electrons may pass out of the nuclear boundary, and if the core is not very stable some of the protons constituting it may get out. H. K. M.

The International Research Council. EDITORIAL. *Nature* **116,** 138–9 (1925).—The International Research Council held its third meeting at Brussels in the Palais des Academies on July 7–8–9. The number of adhering countries is now thirty-one as Tunis and Latvia were admitted at this meeting. Of the total membership, however, only seventeen were represented on this occasion, namely: Belgium, Czechoslovakia, Denmark, Egypt, France, Great Britain, Holland, Italy, Japan, Morocco, Norway, Poland, Union of South Africa, Spain, Sweden, Switzerland, and United States. An account of the meeting is given. H. K. M.

Industrial Chemistry at Wembley. EDITORIAL. *Nature,* **116,** 139–40 (1925).—Comparing the chemical section of the Palace of Industry with that of last year the visitor will notice the same excellent lay-out, though he may regret the absence of exhibits from a number of well known manufacturers. This absence does not, however, seriously impair interest, and in some ways is an advantage, because undue multiplication of similar exhibits is avoided and there is more space available for effective display. On the other hand, the presence of rather an excessive number of vendors of "cures," perfumes, hair washes, and other proprietary toilet articles is apt to confirm the man in the street in his prepossession that chemistry begins and ends with pharmacy.

Among the novelties it is interesting to note that when mixed with powdered limestone, sodium silicate is now successfully used for hardening the concrete surfaces of roads. Sodium silicate is coming into use as a means of preventing corrosion of water pipes and cisterns and of enabling aluminum utensils to withstand the action of hot solutions of soda. It is also used as an adhesive. The exhibits of the "oxylene" process for fireproofing timber is instructive, and the merits of Prof. A. P. Lauries' "silicon ester" as a means of preventing decay of building stone are effectively indicated by specimens of treated and untreated materials. "Silicon ester" is made by the interaction of alcohol and silicon tetrachloride and it acts by depositing silica in the pores of the stone thereby strengthing it but not affecting the permeability. H. K. M.

The Future Science of the Schools. H. E. ARMSTRONG. *J. Educ. and Sch. World,* **57,** 482–8 (1925).—"It is wrong always, everywhere, and for any one to believe anything on insufficient evidence." A. shows how this idea of W. K. Clifford, the ideas of Huxley and of Spencer, and of other leading champions of science of fifty years ago must be recaptured. "No student today studies at the university with any other object than that of getting on in life; the courses are directed to professional, not to cultural, moral ends; moreover, the professional courses are almost entirely didactic—they cannot well be otherwise, so long as the learner is supposed to know but a multitude of facts and is in no way disciplined in the method and spirit of science... Today, the main struggle of the student is to pass an examination. Rational teaching is impossible under the conditions now imposed upon schools. No proper foundation is laid in any subject, no system is developed in the learners' mind; this is just crammed with facts, never disciplined.

"We must depose the Knowledge Idol, as Thring called it. We must get down to bedrock conditions of simplicity. We must devise means, without delay, of bringing some sense of scientific method to the public ken and into public practice.

"Taking the chemistry books written for boys by teachers in schools; most of them present no clear outline, no element of method, no element of insight and understanding derived from practical knowledge of materials, no real thought seems to have been exer-

cised in their preparation; they are built of a mass of undigested, bare facts, copied from previous writers, larded here and there with tid-bits of modern discovery. . . .

"I suppose most teachers of science in the universities and technical schools today would prefer to have boys uncontaminated with school science. . . .On the other hand, I both feel and know that if any early foundation of scientific method could be laid at school it would be invaluable. It would need to be real and solid, honestly learnt, with an honest object in view; as a philosophy and a preparation for life as a whole, as a moral background. . . .To get down to subjects—chemistry, with some physics, has been the stable diet of schools. Geology has been disgracefully neglected. Biology equally so. We need to get rid of all special teaching and deal with the subject generally.

"To make the spirit of science available in schools, and therefore of public avail, a profound change must be made in the university system. A general arts course must be provided, preparatory to any and all professional study, whether of science or of letters. Complaint is too frequently made of the literary shortcomings of workers in physical and biological science—the gross ignorance of the Arts men of all matters scientific passes unnoticed. To achieve such a course, an almost superhuman effort will be required: only the most rigid self-examination, self-criticism, and self-control will enable us to accomplish such an end. Moreover, although the burden of developing a better system is likely to rest mainly upon the body scientific, the whole-hearted co-operation of the teaching fraternity at large must be secured to attain the slightest measure of success." H. K. M.

Teaching Chemistry to Beginners along Historical Lines. R. STERN. *J. Educ. and Sch. World,* **57,** 472 (1925).—S. advocates the development of the subject along historical lines, as she thinks it is most stimulating for young students to realize that such men as Priestley, Dalton, and Faraday were real personalities with real difficulties to overcome before they were world-renowned, and that this method strongly develops the reasoning power of the student. Suggestions for laboratory work are included which indicate the lines along which such a course can be carried out. H. K. M.

Humanism in Science Teaching. F. S. MARVIN. *J. Educ. and Sch. World,* **57,** 488–90(1925).—M. deplores the lack of coöperation, or even community of feeling, between the science and the literary or classical sides of our big schools and colleges. Suggestions, mostly the offering of more history, are made for improving the situation. H. K. M.

Historical Method in School Science Courses. E. J. HOLMYARD. *J. Educ. and Sch. World,* **57,** 490–2(1925).—In order to humanize science, a revolution in the spirit which informs those courses and in the aims which inspire them is necessary. H. thinks the sole scheme which has any chance of success appears to be (1) a training in the philosophy and methods of science for all science students at the universities, and (2) the adoption of the historical method in the teaching of science in our schools. The article explains what is meant by the historical method. H. K. M.

The Personal Element in Teachers' Marks. C. E. HULTON. *J. Educ. Res.,* **12,** 49–55 (1925).—A serious study of the basis for the charge frequently made by parents and pupils in regard to unfairness in teachers' marks. From carefully prepared data the author concludes that teachers are not consistent in giving high or low grades, and the marks are not sufficiently reliable to be used for promotion purposes. The pupils have too much at stake for teachers to continue the use of subjunctive and guess methods of rating.

It is suggested that there should be used standard educational scales and tests and that the essay type of examination be replaced by true-false, multiple-answer, and completion tests. Where objective tests are not available teachers should determine what factors are to be considered and the relative weight to be given to each, so that approximately the same standards may be applied to all. R. M. P.

Analyzing Cause of Student Failure. T. A. BUDD. *Penna. Gaz.,* **23,** 803 (1925).—As a result of a survey of the principal causes of failure of students in the Wharton School, the following five are mentioned and explained: (1) lack of work; (2) too much study; (3) lack of method and ability to concentrate; (4) necessary employment in order to provide funds for student's education; (5) illness. J. HOWARD GRAHAM

Why High-School Pupils Fail. J. D. EDMONDSON. *High Sch. Quart.,* **13,** 235–7 (1925).—Reports from the typical schools of Michigan show a marked difference in the percentages of pupils failing. E. questions the causes. As inspector of schools he has gathered many answers from principals. As a result of this he has listed thirty explanations of the causes of excessive failure. These are stated in terms of policies and practices that the principals consider questionable. J. HOWARD GRAHAM

Vocational Guidance Needed in Universities. J. D. ELLIFF. *High Sch. Quart.,*

13, 231–5 (1925).—The universities are training an increasing number of high-school graduates for an ever increasing number of professions. The author believes that the time has come when more attention should be given to the selection of the student for the professions. Vocational guidance is needed. The average high-school student is, in a certain sense, a selected individual. The freshmen entering college now are younger than those who entered ten years ago. Present day college freshmen may be divided into those who have made a good record in high school; those who go to college because of their friends there or that it is the fashion; and those who have been aptly classified by Dean Reed of the University of Michigan as intellectual hoboes. Failure in adult life is due to one of two causes; failure to choose the right vocation (a choice of the wrong vocation or a choice of none); and failure to make adequate preparation for any vocation. The four years in high school and the two years in the college in the Arts and Sciences are referred to as the veritable springtime of life. Give the student a general or cultural education during this time; lead the student to discover himself; give him the best training possible to fit him for his chosen profession. The author then states the problem in five divisions and follows with ample suggestions for ways and means in solving the problem. J. HOWARD GRAHAM

The Physical Science of Leonardo da Vinci: A Survey. IVOR B. HART. *Monist,* **35,** 464–85 (1925).—An interesting abstract of da Vinci achievements in cosmography, geology, general physics, hydrostatics and hydraulics and mechanics, together with a few biographical notes. A brief description of the peculiar characteristics of the manuscripts are given. T. G. THOMPSON

Relation of Sulfur to Alfalfa Production. OSCAR C. BRUCE. *J. Agr. Res.,* **30,** 937–47 (1925).—The total sulfur content of the soil used, Oswego silt loams, was 0.065 per cent. This is a little higher than the average of Kansas soils. The sulfur applications produced no marked increase in yield or root development, which was taken to mean that sulfur was not a limiting factor on this type of soil. The applications of sulfur increased the acidity of the soil as a rule, but the nitrogen content of the alfalfa tops and the sulfur content of the roots and tops were not influenced, nor was there any increase in the number or size of nodules on the roots. J. W. READ

A Study of the Influence of Inoculation upon the Fermentation of Sauerkraut. O. R. BRUNKOW, W. H. PETERSON, AND E. B. FRED. *J. Agr. Res.,* **30,** 955–60 (1925).—Inoculation of sauerkraut with selected cultures of lactic acid bacteria gave an improved product and reduced the number of foreign organisms and the time of their existence in the fermentation. Inoculation also affected the fermentation products by producing an increase in lactic acid and a decrease in acetic acid and ethyl alcohol, as compared to the uninoculated kraut. J. W. READ

Refractions and Electron Constraint in Ions and Molecules. CHARLES P. SMYTH. *Phil. Mag.,* **50,** 361–75 (1925).—An approximate quantitative measurement of the constraints under which the outer electrons of the atomic shells act in determining molecular structure may be obtained from a consideration of the force necessary to displace the electrons from their position of equilibrium. The force necessary to restore the electron to its original position is proportional to the degree of displacement. Calculations from refractions give a measure of the forces that oppose the displacement of the outer electrons in ions and molecules. With unsaturation the constraint upon the electrons is low. The forces exerted upon shared electrons decrease as the number of underlying shells increases. With a greater nuclear charge but with no increase in the number of underlying shells, the forces increase. T. G. T.

Potassium as Mercury-Vapor Trap. A. L. HUGHES AND F. E. POINDEXTER. *Phil. Mag.,* **50,** 423–39 (1925).—"A liquid-air trap is almost universally used as a means for preventing Hg vapor diffusing back into a vacuum system from a Hg pump. It has been found that a trap lined with distilled alkali metal is as satisfactory a barrier to the passage of Hg vapor as a liquid-air trap. Any alkali metal may be used." Several liters of fairly dry air may be passed through the trap without affecting its power to take up the Hg vapor. Potassium makes an efficient barrier until 150% of its own weight of Hg has been taken up. T. G. T.

A Proposed Model for the Alpha Particle and Some Nuclear Series. R. HARGREAVES. *Phil. Mag.,* **50,** 470–91 (1925).—The atom or nucleus consists of unit positive and negative electrons. The atomic weight, p, as narrowed by the use of a single isotope represents the number of positive electrons in the nucleus, while, q, the atomic number, represents the negative electrons moving as satellites around the nucleus. The difference, $q-p$, is the number of negative electrons that bind the positive units so as to form a structure. In the nucleus all units revolve about a common axis with their relative positions unaltered, due to attractions and repulsions following electro-

static law. A triplane model illustrates the nucleus structure. "In the upper and lower of three parallel equidistant planes equal circles are described by positive electrons; in the middle plane a circle of smaller radius is described by negative electrons, all circles having their centers and common axis perpendicular to the planes. Each circle contains n elements equally spaced; positive lies over positive, but negative elements are in azimuth halfway between the positive. The circles are described with a common angular velocity." "In the α-model the four positive electrons lie at any moment at the four corners of a rectangle; the two negative at the ends of a perpendicular to the rectangle drawn through the middle point. The axis of rotation is a line through the middle of the rectangle drawn parallel to its shorter sides." The negative electrons may be in a plane between the planes of the positive and on a circle of small radius, which gives strong protection to the mere mobile electrons; or the positive electrons may be situated to give the best angular momentum. T. G. T.

The Two-Stage Transformation of Magnetite into Hematite. LARS A. WELS AND OSKAR BAUDISCH. *Phil. Mag.*, **50**, 399–408 (1925).—Ferro-ferric oxide, Fe_3O_4, can be completely oxidized to ferric oxide, Fe_2O_3, at 220°C. The maximum permeability may rise from 2.93 to 3.39, the density of packing of the powders being 1.32 gr./cm.^{3} If ferric oxide is then heated in an inert atmosphere at 550°C. the maximum permeability falls to 1.045. The great loss in permeability is a temperature effect. The ferro-ferric oxide may be heated to 800°C. in an inert atmosphere without permanent loss of permeability. With the first change at 220°C. the ferric oxide had the same structure as the original magnetite. When the second change occurred at 550°, the substance assumed the usual structure for ferric oxide. Thus an oxide of the composition Fe_3O_3 has two structures. "There is room for more oxygen in the atomic arrangement of magnetite without undue strain on the structure," and this explains the formation of magnetic and non-magnetic ferric oxides.

With natural magnetite the first transformation can only be obtained at a high temperature, 800°C. The second stage does not take place. T. G. T.

Best Courses in Chemical Engineering. ANON. *Tech. Rev.*, **27**, 433–4 (1925).—After studying exhaustively the curricula of sixty-five institutions the Chemical Engineering Education Committee of the American Institute of Chemical Engineers reported to the summer meeting of the Institute at Providence, R. I., on June 25, the names of fourteen colleges, universities, or technical schools in the United States offering the best courses in chemical engineering. This is a special report rendered after three years of study.

The fourteen institutions selected are: Armor Institute of Technology, Carnegie Institute of Technology, Case School of Applied Science, Columbia, Iowa State College, Massachusetts Institute of Technology, Ohio State College, Brooklyn Polytechnic Institute, Rensselaer Polytechnic Institute, University of Cincinnati, University of Michigan, University of Minnesota, University of Wisconsin, and Yale.

The Report of the Committee says: "It is evident that colleges of the United States are far from a consensus of opinion as to what constitutes a good course in chemical engineering. In many cases the subject is still a composite of chemistry and mechanical engineering against which the American Institute of Chemical Engineering has set its face. It is to the removal of this conception and to the acceptance of chemical engineering as a branch of engineering that the committee is directing its efforts."

H. C. Parmelee, Editor of *Chemical and Metallurgical Engineering* is Chairman of this committee, which consists of ten members. The above report was the unanimous report of the committee. S. WALTER HOYT

Pension System for M. I. T. ANON. *Tech. Rev.*, **27**, 428 (1925).—After a mature consideration of all phases of the question extending from 1920 to date, the Faculty of the Massachusetts Institute of Technology has expressed its approval of the pension and insurance plan drawn up by a committee of faculty members. The outlined plan has been approved by the Executive Committee of the Corporation and, if this committee likewise approves, details will undoubtedly be put into effect this fall.

After careful consideration the Institute faculty has decided to operate its own plan rather than to join that fostered by the Carnegie Foundation. Other institutions, notably Dartmouth, Harvard, and Princeton, have their own systems.

Briefly the proposed plan is: The Pension Fund shall consist (*a*) of a sum of $25,000.00 to be contributed at once by the Institute; (*b*) of annual contributions by each participating member of five per cent of his salary; (*c*) an annual appropriation and payment to the fund by the Institute of an amount equal to five per cent of the salaries of the staff participating in the Pension Fund.

Members of the instructing staff and such administrative officers as the corporation

may approve are eligible to participate in the fund. The money contributed at once by the Institute under (*a*), together with its accumulation, is to be employed solely as a contingent fund.

Normal retirement for age shall be at 65 years. At that time, the retiring member may receive from the Pension Fund an annual pension equal to the annuity purchasable by the accumulated principal and interest of his annual contributions to the fund plus an additional annuity of approximately equal amount (paid by the Institute's contribution); but in no case shall the annuity exceed $1200.00 per year. Provision is made for the refunding of participant's money in case of resignation or death.

An additional feature is the payment to the family of a deceased member of $5000 under the group insurance plan, cared for by one per cent of the five per cent appropriation of the Institute.

S. WALTER HOYT

Academic Freedom. ANON. *Common Ground*, **4**, 168 (1925).—At a recent meeting of representatives of various college associations at Northampton, Massachusetts, the following resolutions were adopted.

(1) A university or college may not place any restraint upon the teacher's freedom in investigation unless restraint upon the amount of time devoted to it becomes necessary in order to prevent undue interference with teaching duties.

(2) A university or college may not impose any limitation upon the teacher's freedom in the exposition of his subject in the class-room or in addresses and publications outside of the college in so far as the general necessity of adapting all instruction to the needs of immature students, or in the case of institutions of denominational or partisan character, specific stipulations in advance, fully understood and accepted by both parties, limit the scope and character of the instruction.

(3) No teacher may claim as his right the privilege of discussing in his class-room controversial topics outside of his own field of study. The teacher is morally bound not to take advantage of his own position by introducing into the class-room provocative discussions of irrelevant subjects not within the field of his study.

(4) A university or college should recognize that the teacher, in speaking or writing outside of the institution upon subjects beyond the scope of his own field of study, is entitled to precisely the same responsibility as attach to all citizens. If the intramural utterances of the teacher should be such as to raise grave doubts concerning his fitness for his position, the question should in all cases be submitted to an appropriate committee of the faculty of which he is a member. It should be clearly understood that an institution assumes no responsibility for the view of its staff; and teachers should, where necessary, take pains to make it clear that they are expressing only their personal opinions.

S. WALTER HOYT

Chemistry and Sanitation at Mass. Homeopathic Med. Soc. ANON. *Tech. Rev.*, **27**, 425 (1925).—The principal speech at the annual meeting of the Massachusetts Homeopathic Medical Society was delivered by Samuel C. Prescott, Head of the Department of Biology and Public Health at M. I. T.

"Until the middle of the 19th century, food was pretty generally prepared in the home of the consumer. The fact that it is now made in large factories makes the inspection of food products comparatively simple and has greatly increased the degree of sanitation possible."

"The Federal Inspection of Meats began in 1890 when the German government claimed that some of the pork that it had been importing was infected. Another great advance has been made in the constructing and perfecting of cold storage plants which, contrary to the general opinion, are of great aid to sanitation."

"Perhaps the most startling statement made by Professor Prescott was that milk powder will soon be the accepted means of securing lacteal fluid. He admitted that pasteurization was very effective but was quite certain that it will not be long before every one will be buying his milk in little paper packages at the corner grocery."

S. WALTER HOYT

Reaction and Reactivity. E. C. C. BALY. *Rice Inst. Pamphlet*, **12** (No. 1), 35–65 (1925).—A lecture in which a theory is presented to correlate reaction and reactivity with absorption spectra. The theory assumes (1) that every elementary atom is characterized by one or more quanta of energy which are integral multiples of a fundamental unit of energy; (2) atoms gain or lose energy in terms of their atomic quanta and the process of emission or absorption of one quantum by an atom occupies a definite time which is the same for all atoms and may be equated to the Planck constant; (3) when atoms combine together, the total energy loss is shared equally between them,

T. G. T.

Local Activities and Opportunities

University of Colorado. Dr. J. B. Ekeley, head of the Chemistry Department, who left last April to attend the International Convention of Pure and Applied Chemistry in Bucharest and who spent the summer in Paris returned for the opening of the fall term.

Dr. P. M. Dean, who was on sabbatical leave during the past year, spent the greater part of his time working with Prof. Moreau in Paris.

Prof. C. F. Poe has spent the summer doing research work in the Baker Chemical laboratory, Cornell University.

Prof. H. B. Van Valkenburgh did research at the University of Chicago during the past summer.

Dr. Frank E. E. Germann has been granted sabbatical leave for the year 1925–26 and will be associated with the Carnegie Institution of Washington, doing research on the Fluorescence of the Platinocyanides in coöperation with Dr. Edw. L. Nichols, Emeritus Professor of Physics at Cornell University. The research work will be conducted in the Department of Physics at Cornell, Rockefeller Hall, Ithaca, N. Y.

Dr. W. W. Howe has been appointed to fill the position of Dr. Germann during the latter's leave of absence.

Dr. M. S. Carpenter, who was awarded his degree at the University of Colorado in June, has been awarded the fellowship of the Perfume Industries granted to Dr. Boggart at Columbia University.

Dr. J. S. Fulmer, who received his degree at the University of Colorado in September, will be an instructor in our chemistry department this year.

Dr. Margaret Klemme, who received her degree at the University of Colorado in September, will be in charge of the University dispensary at Purdue this year.

Mr. Karl Klemme, who was granted the master of science degree at the University of Colorado in September, will be assistant professor of biochemistry in the School of Pharmacy at Purdue University this year.

Two wings of a modern chemistry building are under construction and will be ready for occupancy in September, 1926.

University of Nebraska. Those of the University of Nebraska chemistry staff to participate in army training service during the summer were: Lieutenant-Colonel C. J. Frankforter who was an instructor at Ft. Des Moines; Captain T. J. Thomspon and Lieutenant Edgar Boschult of the chemical warfare service were in training at Denver, Colorado, for the last two weeks of July.

Doctor and Mrs. Cliff S. Hamilton represented the University of Nebraska chemistry staff at the California meeting of the American Chemical Society. Doctor and Mrs. Hamilton made the outgoing trip by the southern route and returned by the northern.

Professor Henry Wing of Doane College faculty doubly celebrated his 1925 summer. He completed his work at the University of Nebraska for his master's degree in chemistry and took unto himself a wife. Mrs. Wing is the daughter of W. R. Jackson, former State Superintendent of Nebraska.

Twelve of the graduate degrees granted by the University of Nebraska the spring and summer of 1925 went to students majoring in chemistry. The list included ten masters and two doctors. One doctorate went to C. H. Whitnah who sailed in April to his position in Judson College, Rangoon, Burma, India, and the other to Fred Jensen who took the position as associate professor of physical chemistry in Texas A. and M. College, beginning September first.

Students from Nebraska who are con-

tinuing their graduate work in other institutions this fall are: Ralph H. Edee, Frank W. Johnson, and Edmund F. Slatterly at Northwestern University; Elmer E. Fleck at Princeton; and Ralph F. Tefft at Massachusetts Institute of Technology. Two men of the list receiving master's degrees go into industrial work; Henry A. Baehr with a milling company in Kingfisher, Okla., and Joel L. Burkett to Proctor Gamble and Co.

Former students who have visited the University of Nebraska's Department of Chemistry during the summer include Doctor Saul Arenson of the teaching staff of the University of Cincinnati; Doctor M. H. Power of the Mayo Foundation Research Staff and Doctor Ingersol of the teaching staff of Vanderbilt University.

University of Wisconsin. Drs. Elmer O. Kraemer and S. M. McElvain have been advanced to assistant professorships; Dr. E. L. Sevringhaus is now an associate professor of physiological chemistry and Dr. W. H. Peterson has been made a full professor of agricultural chemistry.

In the Department of Chemistry, Drs. C. R. Wise and E. L. Whitford have resigned their instructorships to enter commercial work.

Washington State Association of Chemistry Teachers. The Washington State Association of Chemistry Teachers will hold their annual meeting in conjunction with the meetings of the W. E. A. in Tacoma on October 29th and 30th. The meeting on the 29th will be in the form of a dinner at 6.30 P.M. The business meeting together with papers will be held on the afternoon of the 30th. The executive committee will submit a revised constitution and by-laws at the Tacoma meeting for acceptance.

N. E. O. T. A. The Chemistry and Physics Section of the Northeastern Ohio Teachers' Association will hold their meeting in Cleveland on October 30th. Morning sessions of the N. E. O. T. A. are general and will be held in the Public Auditorium; following this a trip will be made to the Nela Park Laboratories where cafeteria luncheon will be served. An interesting program is planned for the afternoon, among the places to be visited being the Lamp Development Laboratory and the various buildings of Home and Color Lighting Demonstrations and Industrial and Auto Lighting Demonstrations. Several interesting speakers are also listed.

Syracuse University. The Department of Chemistry of Syracuse University has been reorganized on the chairmanship basis. Professor R. S. Boehner is chairman for 1925–6.

There are 547 students enrolled in the class in General Chemistry. During the first week of school those who had studied high-school chemistry, about 200, were given placement examinations as an aid in sectioning them. The lowest 10% have been dropped back with those who had no high-school chemistry. Copies of the placement examination questions will be gladly exchanged with other institutions.

On Sept. 10th, Dr. R. A. Baker addressed the Annual Conference of the Chinese Students' Alliance which met in Syracuse. His subject was "The Probable Future of Chemical Warfare."

University of Florida. Dr. Townes R. Leigh, Head of the Department of Chemistry and formerly Director of the School of Pharmacy, has been elected Dean of the recently created College of Pharmacy at the University of Florida.

Prof. A. P. Black was on leave of absence during 1924–25 doing graduate work at Harvard University. He has returned to the University of Florida.

Dr. H. G. Oddy, formerly lecturer in the Department of Chemistry at the University of Alberta, Canada, is now assistant professor of chemistry at the University of Florida.

Mr. Burton Otte, formerly of the Chemical Warfare Service, has been appointed Curator for the Department of Chemistry at the University of Florida.

Dr. F. A. Gilfillan, formerly of the De-

partment of Pharmacy of the Oregon State College has been elected head of the Department of Operative Pharmacy in the College of Pharmacy at the University of Florida.

Dr. Franklin J. Bacon, who for several years had charge of the Department of Pharmacognosy for Eli Lilly and Company, is head of the Department of Pharmacology and Pharmacognosy in the College of Pharmacy at the University of Florida.

Mr. Ernst Stuhr, a graduate of the University of Nebraska, has been elected instructor in pharmacology at the University of Florida.

Mr. Lymann Fonda, a graduate of Purdue University, has been elected instructor in pharmacognosy at the University of Florida.

Mr. M. B. Natlack, formerly assistant chemist at the Bureau of Standards and recently an instructor in chemistry at the Georgia School of Technology holds a fellowship at the University of Florida in the Department of Chemistry. He will investigate the preservation of citrus fruit juices.

Columbia University. On Commencement Day, June, 1925, President Nicholas Murray Butler laid the corner-stone of Havemeyer Annex, the large new wing of Columbia's Chemistry Building. This wing will contain about one hundred and fifty rooms, most of which (as well as a large part of the main building) will be devoted to graduate instruction and research. It is expected that a description of these new laboratories, which include many interesting features of construction and arrangement worked out by Professor Freas of Columbia, will be available shortly.

The stipend of University Fellowships at Columbia has been increased to $1500 for the academic year. Usually one such fellowship is awarded in chemistry each year. There are also a limited number of special Fellowships and University Scholarships carrying smaller stipends. The greater number of opportunities for graduate students to meet part of their expenses while studying at Columbia are in the form of part-time assistantships. Such an appointment may pay anywhere from $100 to $1000 for the academic year, depending upon the amount of time and responsibility involved. The majority of these part-time assistantships pay either $400 or $500 per year, and carry duties which interfere but little with the holder's opportunity as a graduate student in chemistry.

Chicago Association of Chemistry Teachers. The Chicago Association of Chemistry Teachers, on Sept. 18, discussed with Dr. David Klein of the Wilson Laboratories, "How Far Is Uniformity Desirable in High-School Chemistry?" The point was established that all schools should teach thoroughly the recognized fundamentals so that pupils going from one school to another would not find serious interruption of, nor omissions in, the chemistry already studied.

The question of laboratory practice was much discussed. The practice of taking up laboratory study after the topic has been assigned from the text-book or discussed at length in class was emphatically condemned as wasted time. The pupil should have working knowledge of his laboratory problem but where the topic is assigned from the text before laboratory practice, it means that the pupil learns little from the laboratory practice and furthermore has little incentive to learn. In this manner pupils are denied the training of thinking. Where the text and manual are closely coördinated as most of them are and as many teachers think desirable, the pupil can and does use the text to find most of the data before undertaking laboratory work. Many teachers even permit pupils to use texts in the laboratory for this purpose despite the fact that the scientific method requires that it be derived by laboratory investigation. For these reasons the text and manual coördination subverts the highest values of the laboratory work,

namely; the sense training by original observation of data and the reasoning from facts to warranted conclusions.

Dr. Klein from the standpoint of the public asked the teachers of Chicago to teach a uniform list of fundamentals in chemistry in an experimental way that would deliver the values and appreciation of the scientific method to the pupils.

University of Kansas. Dr. H. M. Elsey, associate professor of physical chemistry, has been granted leave of absence from the University of Kansas for the coming year and will be associated with the Research Department of the Westinghouse Company of Pittsburgh.

University of California. Dr. Russell W. Millar, assistant professor of physical chemistry at the University of California, Southern Branch, recently resigned his position to join the research staff of the Bureau of Mines, Berkeley, California.

Lake View High School. Prof. H. R. Smith, professor of chemistry in the Lake View High School, Chicago, Ill., will give an address at the Wisconsin State Teachers' Meeting in Milwaukee, November 6th, on the "Achievements of Pupils in Laboratory Instruction." This talk will be based on the results of research in teaching carried on last year in collaboration with Mr. W. W. Carpenter of Columbia University.

University of Kentucky. Dr. G. Davis Buckner, newly elected chairman of the Lexington Section, recently declined an offer of the position of research professor of poultry nutrition in the Pennsylvania State College and will remain in his present position as research chemist in the Kentucky Experiment Station.

Benjamin W. McKay, a graduate of Hiram College, received his Master's Degree from the Ohio State University in June, 1925. He has been appointed instructor in chemistry at the University of Kentucky and will assist in the course in General Chemistry.

Manley M. Windsor, formerly instructor in chemistry in the University of Kentucky, has resigned to take a position at the Massachusetts Institute of Technology.

Mr. John Holtzclaw has resigned as instructor in general chemistry and will teach this year in the Anchorage (Ky.) High School.

Dr. J. S. McHargue of the Kentucky Experiment Station read a paper entitled "Manganese and Plant Life" at the Los Angeles meeting of the A. C. S. Dr. McHargue is councilor of the Lexington Section and will report on the California meeting in the near future. He was recently elected Vice Chairman of the Division of Agricultural and Food Chemistry.

The Executive Committee of the Kentucky Chemistry Teachers' Association recently held a meeting at Lexington. Plans were completed for the autumn meeting which will be held at the University.

The addition to Kastle Hall, University of Kentucky, is rapidly nearing completion. The new building will provide added office, library, and research laboratory space, and give new laboratories for the Divisions of Organic, Physical and Quantitative Chemistry.

The new chemical laboratory of the University of Louisville is nearly completed. This building will offer greatly increased facilities for the work of the department.

Prof. V. F. Payne, professor of chemistry, Transylvania College, is the new Secretary of the Lexington Section of the A. C. S. New members of the Section are as follows: Earl Mathias Bilger, prof. of chemistry, Berea College; Elmer L. Huber, Millersburg (Ky.) High School; Cecil E. Bales, Louisville Fire Brick Co., Graham, Ky.

R. N. Maxson, prof. of inorganic chemistry, University of Kentucky, will speak on "Theories of Gel Formation" at the October meeting of the Kentucky Chapter of the Society of Sigma Xi.

Recent Books

Modern Inorganic Chemistry. J. W. MELLOR. Longmans, Green & Co., New York. New Edition, 1925. xx + 1103 pp. 13 × 20 cm. $4.25.

In the midst of the task of producing his comprehensive treatise, Professor Mellor has somehow contrived to bring out a revision of his well known text-book of inorganic chemistry. The new edition differs only in detail from the older one; the titles and order of the chapters are unchanged and even the paragraph headings are the same in nearly all instances. The volume has been enlarged by nearly two hundred pages, the increase consisting in amplification and additions throughout the book. These changes bring the descriptive portions of the text up-to-date, for the most part.

Unfortunately, there are numerous indications that the revision has been hastily made, for one finds in the new edition many of the errors and obscure passages that were in the old edition. For instance, there is an error in the slope of one of the curves in the phase diagram for sulfur (p. 477), and the discussion of transport numbers (p. 374) is very confusing. On page 388 it is stated in both editions that silver deposits on the anode when the electrolyte contains potassium cyanide, this being given as evidence that the silver is in the anion. The statement (p. 410) that there may be a missing element between cadmium and mercury in the second group of the periodic system would appear to be rather mild in these days of atomic numbers. In the section on the preparation of fluorine (p. 330) there is no reference to the newer process depending upon the electrolysis of fused potassium acid fluoride. In the discussion of molecular weight determinations (pp. 257–8) only the older forms of apparatus are given, with no reference to those more recently developed by Cottrell and others. On page 411 there is an unfortunate repetition of several lines almost verbatim. In addition, typographical errors are sufficiently prominent to make one cautious in the use of the physical constants as given.

But in spite of its errors, which are generally obvious to a chemist, and regardless of the fact that the theoretical discussions are often inferior to the excellent portions of the book, the reviewer has been for years an admirer of Mellor's text. To the teacher of general chemistry it is almost indispensable. It contains historically interesting details which are very suggestive; it tells many of those practical minutiae which most texts take for granted without right but, as Emerson remarked, these are the most important things in the world when you are confronted by them. Finally, Mellor is always the chemical philosopher: he never loses an opportunity to teach the method of science, to show its successes and failures, to point to its foundations and goals, and to scrutinize its implements of experimentation and logic.

While Mellor's text does not appeal to the reviewer as a suitable text-book for elementary students, every teacher should have a copy for the sake of the illumination and interest that it will add to his teaching.

G. H. CARTLEDGE

General Chemistry. H. I. SCHLESINGER. Longmans, Green & Co., New York. First Edition, 1925. vi + 631 pp. 31 figures. 21.5 × 13.5 cm. Price, $3.75.

To the reviewer's knowledge this is the only text-book prepared "for students already somewhat familiar with the rudiments of the science." Quoting further from the preface, "Long experience in teaching chemistry to students who have had a year of the subject in high school has convinced the author that they should not be given class work or texts planned for those who have had no chemistry at all. College chemistry for such students should concentrate on the fundamental phenomena and principles, and on the simpler applications which can be discussed with some degree of thoroughness."

Following in the path of Doctor Stieglitz's procedure with his beginning analytical chemistry, the author suggests opening "the course with two weeks of daily lectures and no laboratory work." "The class-room work is, of course, supplemented by laboratory instruction" and a laboratory manual to accompany this text is promised.

The method of the text is that of the formal logical type using the definition and theory as a starting point in the largely deductive synthesis of the body of principles set forth. The language is generalized rather than specific; the illustrations, both in figures and appeal to specific experiences of the students, are scattering and almost negligible. In other words, the author has made no effort to "humanize" his subject.

Accepting his method, the author is to be commended for a book that is clear cut, concise, and consistent in its treatment. If appeal to students' experience is beneath the dignity of a college course in chemistry then each chapter's exercises are teachable and a great aid to further development in chemical abstract reasoning

In content the following chapter headings i-di-

cate the correctness of the name General Chemistry: Radio-activity, Carbon (twenty-three pages), The Colloidal Condition, Metallic Elements, Alloys and Electro-Chemistry. These are in addition to the usual first-year college content.

While a helpful paragraph upon "Method of Study" is given at the end of the introductory chapter, the author has missed an excellent opportunity to train students in the art of study in failing to use cross references. In that connection it is not amiss to regret the omission of all section numbering.

Two very excellent features of the book are the specific and stimulating reading references found at the end of each chapter and the very full and usable index. The latter, in no small measure, compensates for the omissions noted in the last paragraph.

Mechanically, the book is well done: the paper is of good quality, the binding substantial and the type selection helpful. College teachers generally will find much in this text that will help them to more effective teaching.

B. CLIFFORD HENDRICKS

TO BE REVIEWED LATER

Chemistry in Everyday Life—Emery, Davis, Boynton, and Downey.

Applied Chemistry, A Laboratory Manual—Emery, Boynton, and Miller.

How to Teach General Science—Frank.

Quantitative Analysis—Hendel.

Tests Show Women Students More Unstable than Men. While reliable means of intelligence testing have put to flight old-fashioned ideas of male superiority, recent psychological tests at Colgate University have revealed that men still have the edge in emotional stability. Donald A. Laird and Thomas McClumpha, in testing six hundred men and about 400 women students, found that women have far many more artificial emotional outlets than men. Men live their emotions while women think theirs.

Twenty per cent more women pretend spurious mental fatigue than men; ten per cent more women are introvert; more women, too, were neurasthenic. But hysteria was about as common with one sex as with the other.

Although the women made by far the worse showing in these college tests, in the country at large the occurrence of extreme emotional instability as shown in insanity is greater with men. Messers. Laird and McClumpha suggest it might be that the emotionally unstable type of women are attracted by higher education.

Another theory suggested is that the male preponderance of insanity in the general population is not a true test of emotional equipment because men are as a class more exposed to hazards that result in insanity. It has been shown that eight times as many men are confined for insanity due to physical injury, and five times as many on account of social diseases. When these are eliminated the scale tilts slightly to the other side and more nearly agrees with the college findings.

The experimenters are not satisfied that this disparity is due to sex, but see the possibility of it resulting from a difference in social conditions. Mr. Laird said, "From earliest childhood the restraints and training of the sexes differ and the difference we find in middle adolescence may be a reverberation of this early environment. Our data cannot be interpreted as showing that there are innate differences, the differences may be acquired. The trend of opinion is that the emotional outlets such as we are testing are acquired."—*Science Service*

"A Few Moments with the Business Manager"

LOUISIANA STATE UNIVERSITY
AND
AGRICULTURAL AND MECHANICAL COLLEGE
BATON ROUGE, LA.

July 17, 1925

DEAR MR. BILLINGS:

You ask me to give you my frank opinion of the *Journal*. I have no objection to doing this. While I think the *Journal* will doubtless improve in the future, I have been astonished at its success and unusual merit so early in its life. The *Journal* shows excellent quality. It also meets a very distinct demand, which demand will grow as the means of satisfying it are improved. I have often thought that we know singularly little of the pedagogy of chemistry. You cannot teach it in the same way you teach any other subject I am acquainted with. All of us seem to feel that we ought to get better results than we do, but none of us seem to know just exactly where the trouble lies. Already we have begun to swap ideas and this will enable us to avoid certain general mistakes.

It will give me pleasure to do anything I can for the success of the *Journal* which I believe will increase with the years.

Yours sincerely,

CHARLES E. COATES,
Head of Department of Chemistry

STANDARD OIL COMPANY

Research Laboratory,
Whiting, Indiana

DEAR SIR:

I have greatly enjoyed going through the July number of the JOURNAL OF CHEMICAL EDUCATION which you kindly sent me. It is very gratifying to all those interested in better chemical education to know that in the future, thanks to the new *Journal*, not only research workers but teachers may have the inspiration which comes to every professional worker in the exchange of new ideas and the results of educational experiments. I hope that the latter important kind of work will be greatly stimulated.

I was especially interested in Mr. Brinkley's paper on the application of the electron concept to oxidation-reduction reactions. I think he is quite right in saying that the electron concept is really simpler than the older views to those who have not been brought up on the latter. I, indeed, hope someone will soon have the courage to start beginners on the Lewis-Langmuir theory and build up the essentials of the science by deductive reasoning confirmed by demonstrations. Such a method should arouse the interest of the beginner and prevent his being overwhelmed by a mass of unrelated and apparently illogical details.

Very truly yours,

ROBERT E. WILSON

"Our Shopping District"

Last October, ten companies displayed their wares on five pages. This year twenty-eight companies are advertising on twenty-one pages. There will be more next month and with the coming of January, several new names will be noted in our table of contents. Advertisers take space only in magazines which will yield results. Apparently our readers not only read the signs in the "Show-Windows" of our *Journal* but buy from the concerns which display their goods with us.

Another reason why our "Shopping District" is growing is that the reading population (number of subscribers) of this District is increasing. We have twice as many readers now as we had last year. Will you help us double again during the coming year? If you will, the way is simple; just tell your friends about the JOURNAL OF CHEMICAL EDUCATION and how it will be of genuine assistance to them. That will help both you and the *Journal*.

There have come many excellent suggestions to this Office from advertisers and subscribers. This coöperation will make the JOURNAL OF CHEMICAL EDUCATION continue to grow until every teacher of chemistry in English-speaking countries will feel greatly handicapped without it.